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Mobile Radio Technology™

The journal of mobile communications technology

Low-loss coaxial cables, p. 10

Servicing pagers
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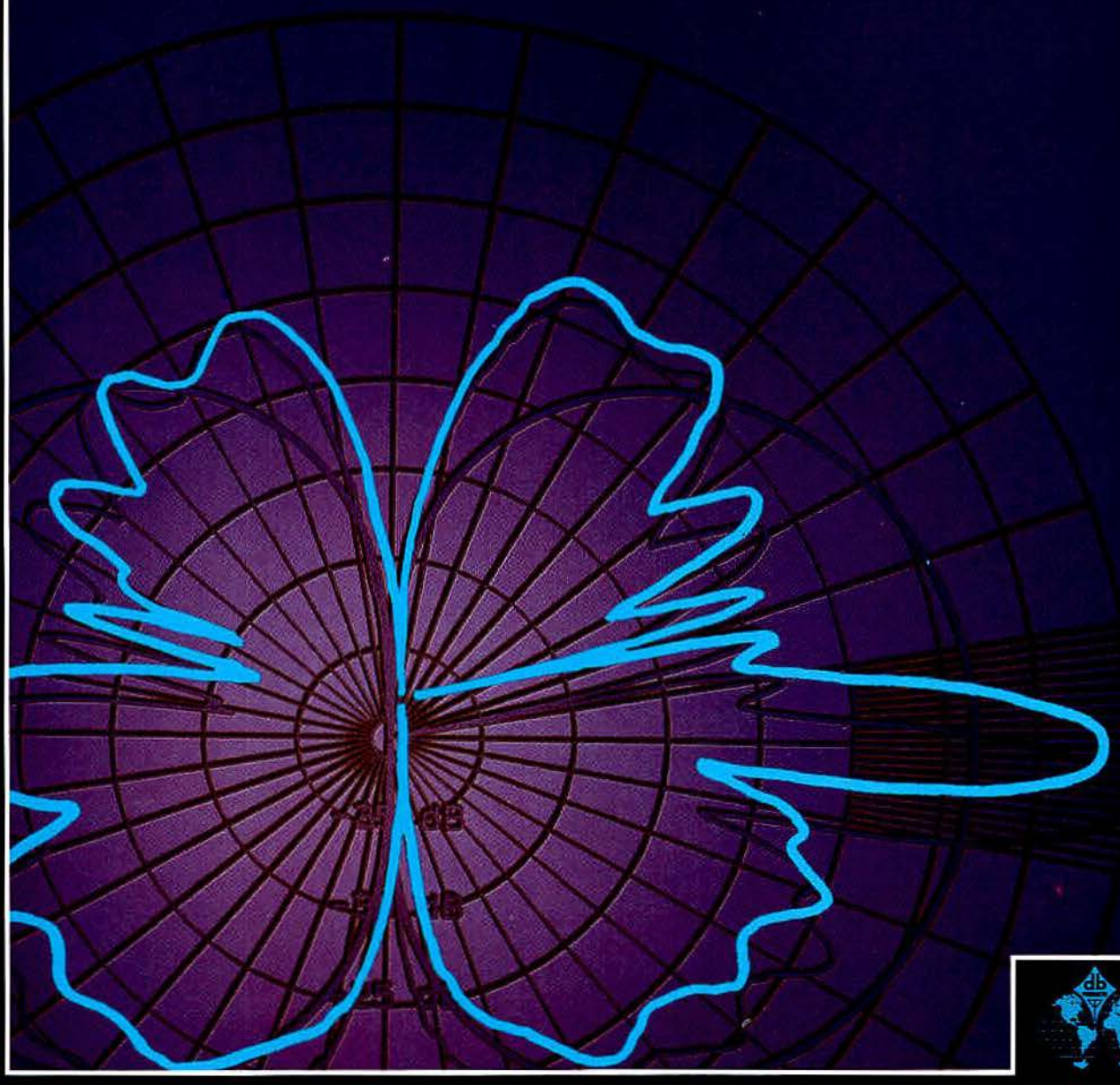

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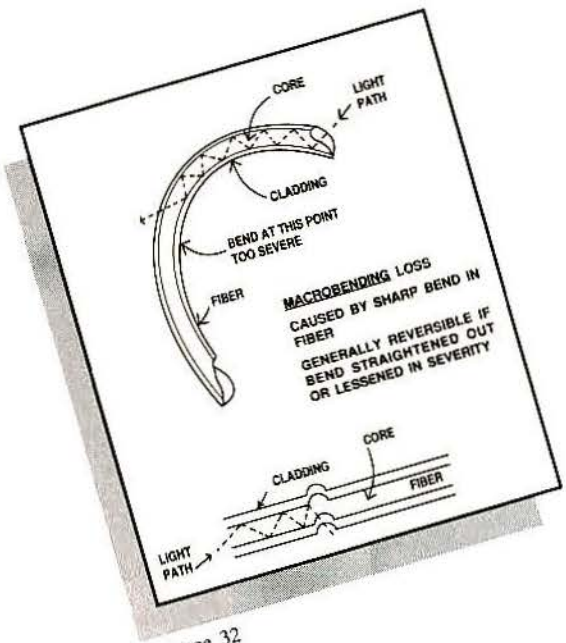
Contents

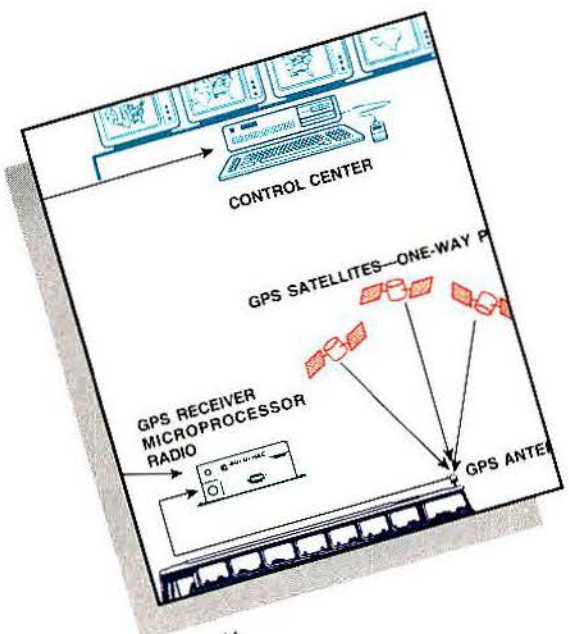
Mobile Radio Technology

Volume 12, Issue 5

The journal of mobile communications technology



page 32



page 44

features

10 New low-loss cables for mobile radio systems
Joe Lanoue and Robert Perelman
Cables with low-loss foam dielectrics and combination foil-braid outer conductors represent an important advance in low-loss cables.

16 Servicing pagers: The receivers
David Ludvigson
Part 5—Here are some tips for identifying which frequency bands correspond with which receiver boards in Bravo pagers.

28 Rechargeable batteries: NiCd and nickel-metal hydride
Isidor Buchmann
Part 1—Here are some comparisons between NiCd technology and a challenger.

32 What technicians should know about fiber-optic installation
Wayne R. Gipson, C.E.T.
Part 2—Here is some helpful information about cable specifications, splices, connectors and power budgets.

44 Track fleet movements with a PC mapping system
John Mansell, Pat Friend and Jacqueline Jones
A flexible personal computer mapping system uses advanced vehicle locating and tracking technologies to form an integrated AVL system.

On the cover: Various types of coaxial cables fit wireless communications system requirements. See Joe Lanoue and Robert Perelman's article on page 10. *Photo courtesy of Times Microwave Systems, Wallingford, CT.*

58 Departing from 'old-school' automatic vehicle location
James A. Pautler
Opening vehicle location to the mass market requires new thinking and new technology.

departments

4 Editorial

6 Calendar

8 Technically speaking
Harold Kinley, C.E.T.
Impedance, admittance and the Smith chart—Part 1.

68 Regulating Technology
Robert H. Schwaninger Jr.
Big Brother and the Holding Company.

70 News
Midland alters distribution; adds antennas, hand-helds.

72 New products
Panasonic and Antenna Specialists are the "Readers' Choice."

81 Literature

82 People

83 Letters from readers

84 Classified ads

104 Ad index/hot line
Find advertisers quickly.

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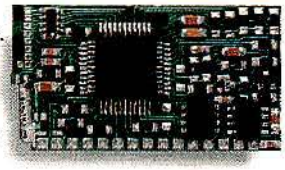

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Technician licensing might lead to proper *transmitter* licensing

Remember land mobile technician licensing? It's coming back, if two user-group organizations based in Arlington, VA, get their way.

A Petition for Rulemaking filed by the Industrial Telecommunications Association (ITA) and its affiliate, the Council of Independent Communication Suppliers (CICS), asks the FCC to require that adjustments coincident with installation and servicing of stations in the Private Land Mobile Radio Services be performed by, or under the supervision of, a person licensed by the commission.

Until 1984, the FCC had administered a similar licensing program, but discontinued it in favor of industry certification. The proposed licensing requirement would be in addition to current industry programs for certification of radio technicians.

Transmitter licensing

According to ITA and CICS, instituting FCC licensing would help reduce unlicensed operation of radio facilities on private land mobile frequencies. The petition maintains that licensed radio technicians have more incentive to inform their customers about the FCC's operating and licensing requirements. Also, FCC licensing would introduce what ITA and CICS characterize as "a heightened sense of professionalism among maintenance and service personnel, because their chosen profession has been raised to a level warranting licensing by the FCC."

The petition claims that an effective licensing program would "provide a useful means of ensuring competence" and "a bona fide incentive among radio maintenance and service personnel to comply with FCC regulations." Under present circumstances, the petition reads, "the FCC has no effective leverage over maintenance and service personnel who may promote unlicensed operations." Service personnel would have an official FCC license to "protect," according to the petition.

Reasons for lack of license

Equipment may be unlicensed for several reasons. First, an original license may have expired. Second, company ownership may have changed without the requisite paperwork being filed with the FCC to transfer radio licenses to the new owner. Third, additional radio units may have been added beyond the specified number without modifying the license. Fourth, hand-held radio units may have been acquired by mail or from retail outlets, and the purchasers may have ignored the enclosed license application form.

These reasons probably account for a majority of unlicensed equipment. Activation of private radio networks without initial licensing, a fifth reason, probably accounts for relatively few unlicensed units, although it is a matter that might be affected by the same action of technician licensing.

Mary Kjorvestad, vice president of Empire Mobile Communications, Houston, and chairman of the Unlicensed Operators Task Force formed by the Alexandria, VA-based National Association of Business and Educational Radio (NABER), is skeptical about licensing.

"I think technicians will like the idea," she said, "but I don't think it will solve the problem. It comes down to self-policing, the desire to do the right thing for the higher good, and because it *is* the right thing to do, no matter what license is required."

Technicians who are working under supervision, she said, generally do not help customers to circumvent license requirements. When such conduct is found, she said, it sometimes is found in one-person businesses where the owner is the technician and sometimes where a technician may be working "on the side" for extra money without the employer knowing about it.

Money

As with any licensing program, eventually the question comes down to money. Can the FCC allocate the necessary funds to develop a new licensing program? How much will applicants be charged? Will all applicants have ready access to test locations? "Licensing may punish some technicians who cannot take the time to get a license," Kjorvestad said.

At least one FCC official has indicated that the time "may be right" to reinstate licensing for land mobile radio technicians.

There may be an easier way. Why not simply reinstate the requirement that radio communications technicians have an FCC General Radiotelephone Operator License? "I would be comfortable with that," Mark E. Crosby, the president of ITA, told us. "The point is to bring back the integrity to the service industry by giving technicians a reason to say 'no' when they are asked to work on unlicensed equipment."

Crosby said if the petition is put out for comment by the FCC, people who respond may offer alternatives that would accomplish the same goal as a new FCC license for land mobile radio technicians.

Send us your ideas, too, and we'll print them for others to read.

—Don Bishop

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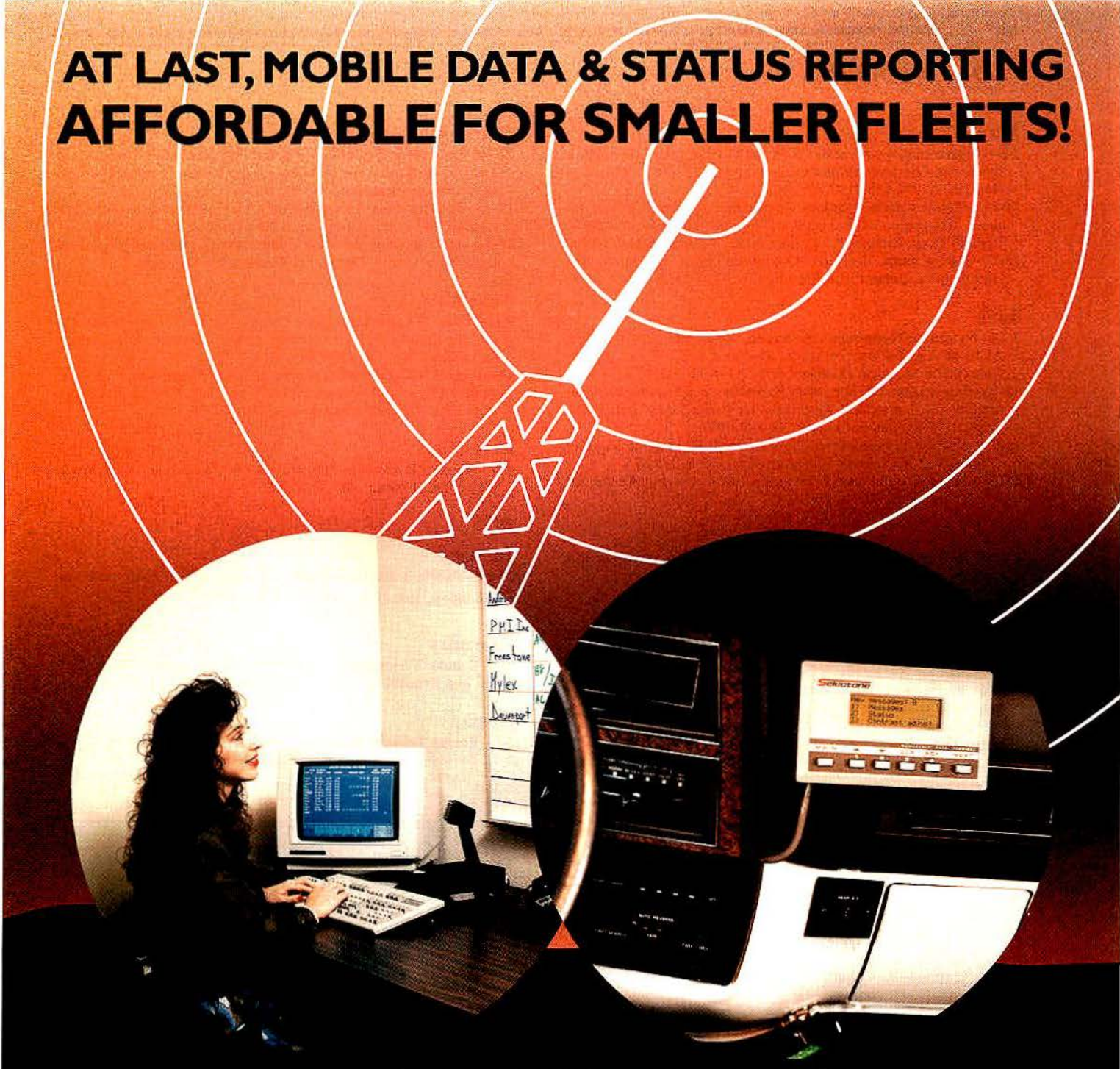

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Calendar

May

2-5—Supercomm, sponsored by USTA and TIA, and **International Conference on Communications,** sponsored by IEEE, New Orleans. Contact: USTA, 202-835-3100.

11-14—Mobile Communications Conference, sponsored by the National Association of Business and Educational Radio (NABER), Peabody Hotel, Orlando, FL. Contact: Nancy Palleschi, 800-759-0300.

25-27—RadioComm, Vancouver Convention Center, Vancouver, British Columbia. Contact: Bill Eggertson, 613-233-4888.

June

7-11—Vehicular Technology Conference, sponsored by IEEE Vehicular Technology Society, Stockholm, Sweden. Contact: Professor Sven-Olof Ohrvik, technical chairman, 46 8 757 0483; Fax 46 8 34 8441.

18-20—International Public Safety Exposition and Conference, sponsored by the International Association for Public Safety, Dallas Convention Center, Dallas. Contact: 203-847-9679.

19-23—Utilities Telecommunications Council, Washington Sheraton, Washington, DC. Contact: Christine Benz, 202-872-0030.

28-30—Wireless Datacomm Spring, San Jose Convention Center, San Jose, CA. Contact: 800-322-9332.

July

17-20—Forestry-Conservation Communications Association, Hershey, PA. Contact: Don Pfohl, 602-644-3166.

August

6-11—International Municipal Signal Association, Cavenaugh's Inn, Spokane, WA. Contact: Harold Glerum, 800-723-4672.

7-12—Association of Public-Safety Communications Officials—International National Conference, Lawrence Convention Center, Pittsburgh. Contact: 800-824-1850.

September

22-24—Mobile Communications Marketplace, Washington State Convention Center, Seattle. Contact: 800-326-8638.

October

3-5—WirelessWorld Conference & Exhibition, sponsored by *Cellular Business* magazine, The Stouffer Orlando Resort, Orlando, FL. Contact: Stephanie Hanaway, 913-967-1856.

15-20—International Association of Chiefs of Police, Albuquerque Convention Center, Albuquerque, NM. Contact: 703-243-6500.

19-21—International Wireless Communications Expo/Fall, Tampa Convention Center, Tampa, FL. Contact: 303-220-0600.

November

9-13—CMA '94, sponsored by the Communications Marketing Association, Radison Plaza Lord Baltimore Hotel, Baltimore, MD. Contact: Jack Armstrong, 410-628-9300.

18—Radio Club of America, Communications Symposium, 85th Anniversary Dinner and Awards Presentation, New York Athletic Club, New York: Contact: Ron Formella, 201-652-6811.

December

6-8—Wireless Datacomm Fall, Washington Convention Center, Washington, DC. Contact: 800-322-9332.

1995

January

22-26—Pacific Telecommunications Council (PTC) conference and exhibition, Honolulu. Contact: 808-941-3789.

February

1-3—Cellular Telecommunications Industry Association Winter Meeting and Exposition, New Orleans. Contact: 202-785-0081.

April

3-5—Energy Telecommunications and Electrical Association, George R. Brown Convention Center, Houston. Contact: 214-235-0655.

Mobile Radio Technology

The journal of mobile communications technology

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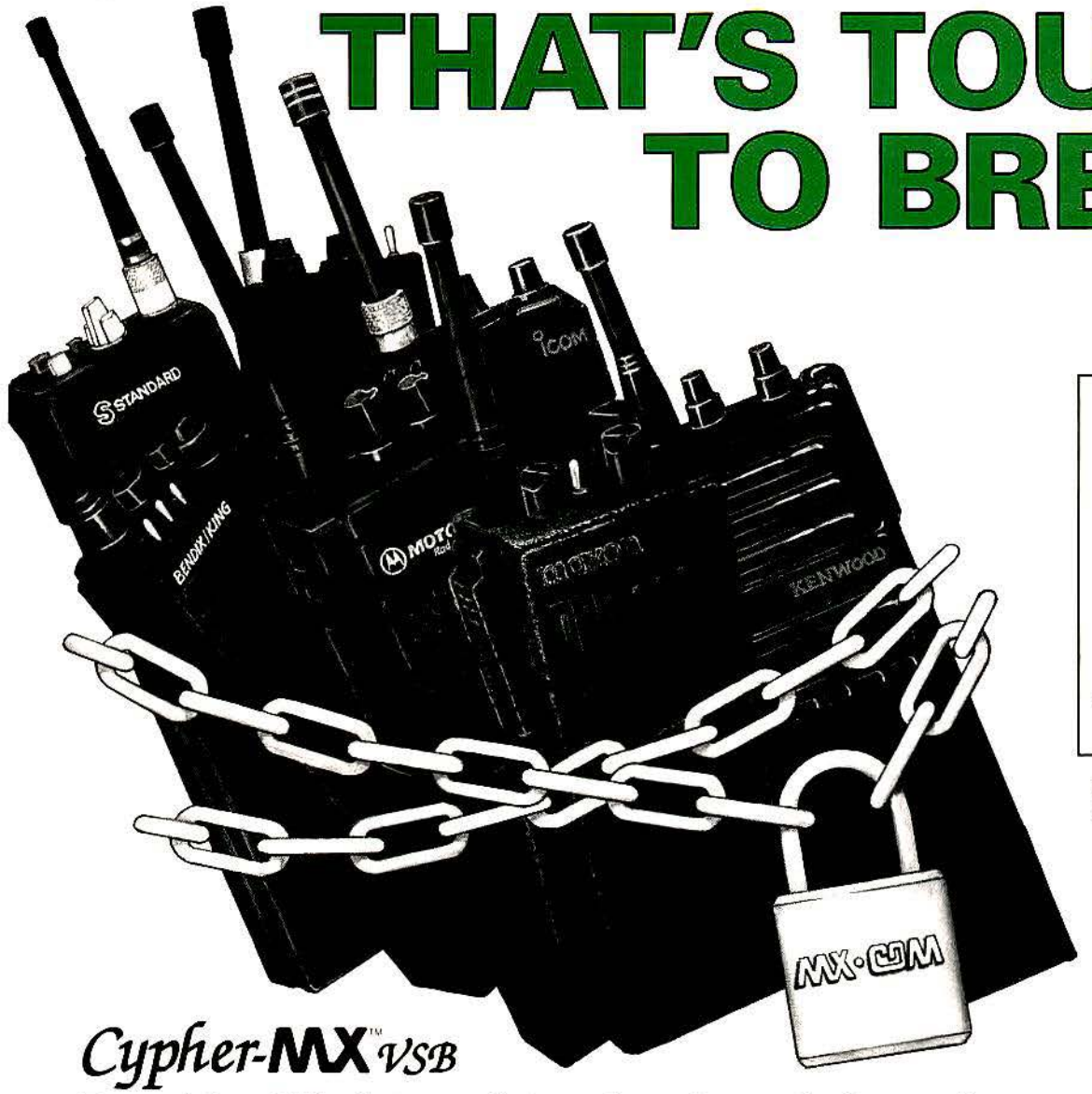

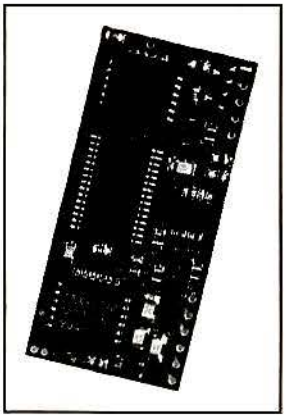

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Impedance, admittance and the Smith chart—Part 1

By Harold Kinley, C.E.T.

One of the first things we were taught in radio-electronics school was the principle of impedance matching for maximum power transfer between a generator and its load. According to this principle, maximum power transfer occurs only when the impedance (Z) of the load matches the internal impedance of the generator.

Impedance

Impedance can be purely resistive, or it can consist of a *resistive* **and** a *reactive* component. An impedance of this type is called a *complex* impedance. (See Figure 1A below.) Here, a 50Ω generator is terminated in a complex impedance consisting of a 50Ω resistor and a 15Ω capacitive reactance. This termination could represent an improperly matched or mistuned antenna connected to the transmitter. Because the generator's internal impedance is a pure resistance of 50Ω, it must see a purely resistive 50Ω load before maximum power transfer will occur.

Although the output impedance of a transmitter (generator) may not be 50Ω, it is usually designed to *work into a purely resistive impedance of 50Ω* (or whatever the system impedance may be). For the sake of this discussion, let's say the output impedance is 50Ω.

Complex impedances are written as $R \pm jX$ where R is the resistive component expressed in ohms, and X is the reactive component expressed in ohms. Capacitive reactance is written as $-jX$, and inductive reactance is written as $+jX$. (Remember ac circuit analysis back in radio-electronics school? It's still valid!) The complex load impedance of Figure 1A would be written as $(50 - j15)\Omega$. To transform the load impedance to a pure resistance of 50Ω, we could add an *inductive* reactance of 15Ω $(+j15)\Omega$ in series with the 15Ω capacitive reactance to effectively cancel out the reactance component $(-j15 + j15 = j0)$. This makes the load a pure resistance of $(50 + j0)\Omega$, or simply 50Ω. (See Figure 1B).

Complex impedances connected in series are additive in the *complex* form. For example, if two complex impedances, Z_1 and Z_2, are connected in series, the *resultant* impedance, Z_T, can be found by algebraically adding the two impedances in the complex form. Suppose that Z_1 is $(50 + j25)\Omega$, and Z_2 is $(30 - j40)\Omega$. The total

(continued on page 52)

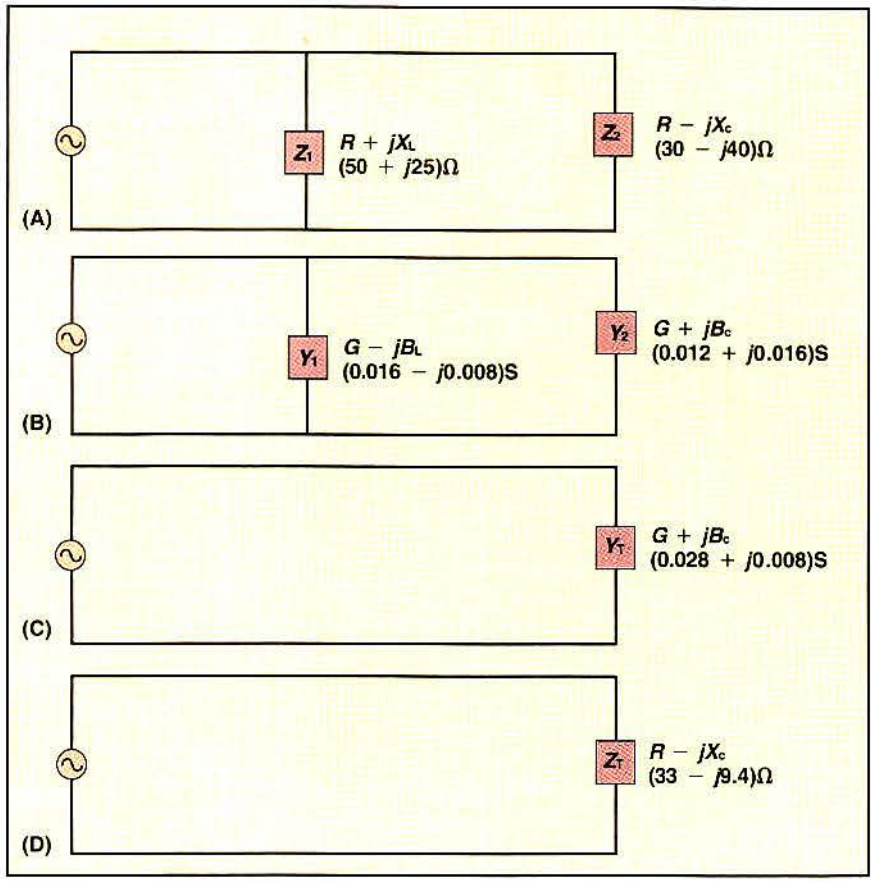

Figure 3. Two complex impedances connected in parallel.

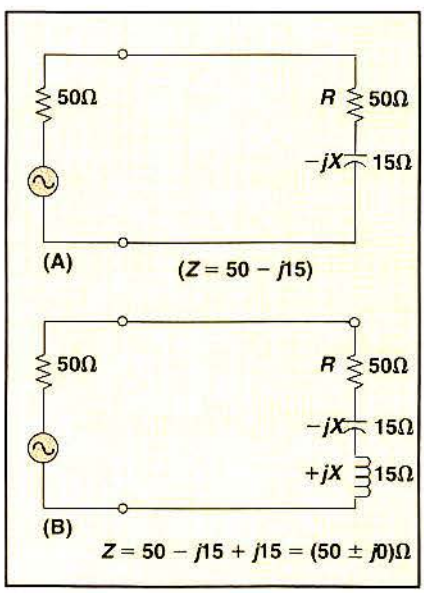

Figure 1. A complex impedance.

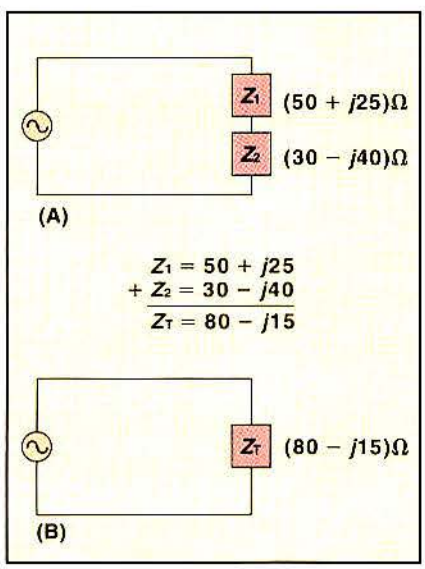

Figure 2. Two complex impedances connected in series.

Kinley is a certified electronics technician with the South Carolina Forestry Commission, Spartanburg, SC. He is the author of *Standard Radio Communications Manual: With Instrumentation and Testing Techniques*, Prentice-Hall, 1985.

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New low-loss cables for mobile radio systems

New cables with low-loss foam dielectrics and combination foil-braid outer conductors represent the first important advance in low-loss cables in more than 10 years. Mobile radio system owners will appreciate the cost savings.

By Joe Lanoue and Robert Perelman

Low-loss coaxial cables are ideal for antenna feeders and interconnects in land mobile, cellular and paging systems. The traditional choices have been foam- or air-dielectric cables with corrugated-copper outer conductors and air-dielectric cables with combination foil-braid outer conductors.

Corrugated-copper cables are expensive. They require special connectors and are stiff, making them difficult to install. Recently, air-dielectric cables with foil-braid outer conductors have gained popularity because they are less expensive than corrugated-copper cables, they use inexpensive standard connectors, and they have good flexibility.

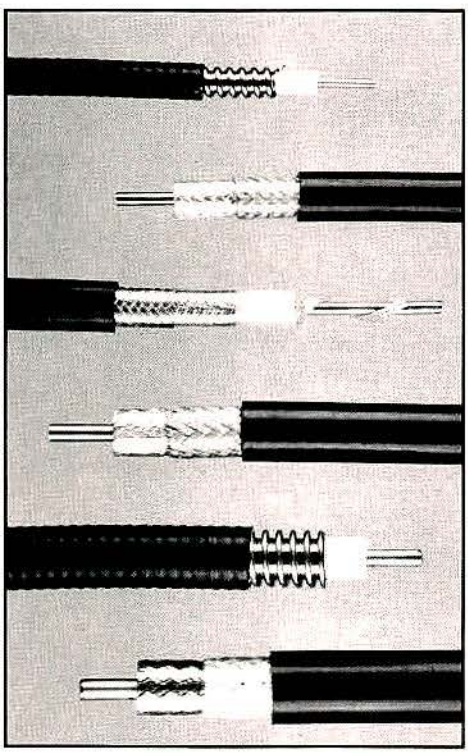

Photo 1. From top to bottom: Andrew FSJ1-50A cable , Times Microwave Systems LMR-400 cable, Belden 9913 cable, Times LMR-500 cable, Andrew FSJ4-50B cable, and Times LMR-600 cable.

Even so, air-dielectric cables have shortcomings. Their construction typically consists of a center conductor with a strand of polyethylene wound helically around it, a tube of polyethylene extruded over that combination, a bonded foil and braid outer conductor over that and, finally, a polyvinyl chloride (PVC) jacket, as shown in Photo 1 to the left (third from the top). Because the cable has a continuous air space along its length, moisture can accumulate inside and degrade the cable's electrical performance when it is installed outdoors. The center conductor is not bonded to the dielectric, so it can move toward the outer conductor when the cable is bent, changing the cable's electrical performance.

Temperature changes can cause the center conductor to protrude from the outer conductor, especially when the cable is outdoors. This protrusion can prevent the connector on the cable from making proper contact with its mating connector.

Air-dielectric cable is available in a 0.405" diameter with attenuation approaching that of a ½"-diameter corrugated-copper cable. For applications requiring lower loss, corrugated-copper cables were the only solution—until now.

A new series of cables fills the gap. Low-loss foam dielectrics and foil-braid outer conductors give the new cables losses comparable to corrugated-copper cables at a much lower cost. They use inexpensive connectors that are modified standard RG cable connectors. The cables are available in sizes ranging from 0.200" to 1.670" in diameter, but this article focuses on the LMR-400 0.405" and LMR-600 0.590" sizes, which were developed first.

The new cables avoid the problems of air-dielectric cables through the use of a proprietary, low-loss, polyethylene foam. The result is loss lower than for an air-dielectric cable of the same size and virtually identical to that of a corrugated-copper outer conductor cable of the same size. The foam materials and processing have been developed to maintain good strength so that the cable is rugged enough to withstand normal installation. The use of a foam instead of an air dielectric eliminates problems with moisture ingress. By bonding together all of the cable components, problems with differential expansion and conductor migration during bending are also avoided.

The jacket on these cables is black, low-density polyethylene with 3% carbon black added for ultraviolet light protection. This is the same jacket material commonly provided on corrugated-copper cables, and it has proven to be durable for outdoor installations, with a life expectancy in excess of 20 years. Air-dielectric cables are commonly provided with PVC jackets of various types. These exhibit less weather resistance than polyethylene and, if not properly formulated, can result in degradation of electrical performance over time due to migration of the plasticizer into the dielectric.

The biggest difference between the new cables and the corrugated-copper cables is the outer conductors. Corrugated copper is a proven performer in outdoor applications. So is foil-braid—this basic construction has an excellent record of trouble-free

Lanoue is manager of product design engineering, and Perelman is manager of commercial sales and marketing, at Times Microwave Systems, Wallingford, CT. Perelman is a member of the Radio Club of America.

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service in millions of feet of cable TV (CATV) drop wire installed during the past 20 years. In the new cable's construction, the aluminum tape is bonded to the polyethylene dielectric. This bonding avoids the air gap found between the outer conductor and the dielectric on corrugated-copper products and provides a reliable moisture barrier to protect the dielectric. Extensive humidity testing has been done on these cable constructions to verify that there is virtually no change in their electrical performance over time in a harsh outdoor environment. A high-coverage tinned-copper braid is applied over the aluminum tape for mechanical protection and for connector attachment.

The construction results in excellent RF shielding and phase stability over temperature. The foil-braid outer conductor of the new cables and of air-dielectric cables provides better than 90dB of RF shielding, which is more than adequate for most applications. Corrugated-copper cables provide shielding well in excess of 120dB. When the highest possible shielding is required, corrugated-copper cables may be required.

Phase stability with temperature is mainly a function of the dielectric material used in the cable. Both the common corrugated-copper cables and the new cables use similar low-loss polyethylene foams and have excellent phase stability with temperature—typically better than 10 parts per million per degree Celsius.

When bent excessively, the corrugated copper cables kink easily, causing permanent damage. The new cables use a thicker jacket to provide strength and are virtually immune to kinking.

Crimp and clamp connectors are available for the new cables. The use of a high-coverage braid combined with an adhesive-backed shrink tube results in a high-strength, weather-proof interface between the cable and the connector. For the 0.590"-diameter cable, typical connector pull-off strength is in excess of 100 pounds.

Connectors for the 0.405"-diameter air-dielectric cables also will fit the new cable with the same diameter. These connectors are available from several manufacturers with different interface types and attachment methods. A sample of the types and part numbers is shown in Table 1 below. Connectors for the 0.240" diameter cable are also shown in the table. The 0.590"-diameter cable has a non-standard dielectric diameter, so our company has worked with several manufacturers to design connectors for it. The connector types available include N-male, N-female, UHF-male and 7/16 DIN male in both crimp and clamp-solder configurations. These connectors are

CONNECTOR	LMR-240		LMR-400	
	CLAMP	CRIMP	CLAMP	CRIMP
N (plug)	R. RFN-1004-NX R. RFN-1004-1SX	R. RFN-1007-SX R. RFN-1007-1SX	R. RFN-1002-1SI A. 82-202-1006 TP. 1005-1107-1	R. RFN-1006-3I
N (jack)	R. RFN-1026-X R. RFN1026-1X		R. RFN-1024-1SI	
N (rt. angle)				R. RFN-1009-3I
UHF (plug)	A. 83-59SP A. 83-750 A. 83-59SCP A. 83-168(adapter) R. RFU-500 R. RFU-501 R. RFU-531 (adapter) R. RFU-531S (adapter)	R. RFU-508-X	A. 83-8SP K. KU-51-07 K. KU-59-55 K. KU-59-22 K. KU-51-01 K. KU-51-02	R. RFU-507-SI A. 83-822 A. 83-1SP A. 83-1SPN A. 83-756 A. 83-851 K. KU-59-42 K. KU-59-52 K. KU-59-40 K. KU-59-82
UHF (rt. angle)			A. 83-67 A. 83-59	
Mini-UHF (plug)		A. 81-114		
Mini-UHF (jack)		A. 81-117		
BNC (plug)	R.RFB-1101-1X R.RFB-1101-X	R.RFB-1107-1P	R. RFB-1101-1SI	
TNC (plug)	R.RFT-1201-X	R.RFT-1203-1X		
TNC (jack)		R.RFT-1213-X		

R. = RF Industries A. = Amphenol K. = Kings TP. = Trompeter

CONNECTOR	LMR-400		LMR-500	LMR-600		LMR-1200	LMR-1700
	Clamp	Crimp	Clamp	Clamp	Crimp	Clamp	Clamp
N (plug)	TC-400-NMC	TC-400-NM	TC-500-NMC	TC-600-NMC	TC-600-NM	TC-1200-NMC	
N (jack)	TC-400-NFC	TC-400-NF	TC-500-NFC	TC-600-NFC		TC-1200-NFC	TC-1700-NFC

Note: All standard connectors have silver-plated bodies with gold-plated center pins.

Table 1 — Cable sizes and their corresponding connectors from various manufacturers.

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available from distributors that handle the cables.

Applications for the new cables range from short jumpers between ports on a combiner, to longer jumpers between combiners and radios, to feeder runs up towers. Their combination of low-cost, excellent electrical and mechanical properties and ease of handling make them good choices for many applications where corrugated copper cables have been used.

For example, a large radio manufacturer has selected the new 0.590"-diameter foil-braid cable to replace a 10-foot jumper previously fabricated from ½"-diameter "superflexible" corrugated-copper cable in a 220MHz system. The 0.590" cable is nearly as flexible as the ½" "superflexible" corrugated-copper cable, but it has a loss of only 1.2dB/100ft at 220MHz compared to loss of 1.6dB/100 feet for the ½" corrugated-copper "superflexible" cable. The new cable's loss is almost as low as that of a ½" low-density foam-dielectric cable that has loss of 1.05dB/100 feet at 220MHz.

The list price of the 0.590"-diameter foil-braid cable is $1.20 per foot. The type-N male crimp connectors used on this assembly are $14.50 each (list price).

Several trunked radio system operators are planning to use the 0.590"-diameter cable for short antenna feeder runs at 900MHz in applications where they previously have used ½"-diameter, low-density, foam-dielectric corrugated-copper cable. The attenuation of the 0.590" cable is slightly higher—2.5dB/100 feet at 900MHz—compared to 2.2dB/100 feet for the ½"-diameter corrugated-copper cable, but the 0.590" foil-braid cable costs less ($1.20/foot, list) and is more flexible. The standard hangers and grounding straps sold for the ½"-diameter corrugated-copper cable also work with the 0.590" foil-braid cable.

A large manufacturer of paging equipment is evaluating the replacement of ¼"-diameter and ½"-diameter corrugated-copper "superflexible" cables with the new 0.405" and 0.590" cables, respectively. For a 20-foot assembly, the material cost is $53 for the foil-braid cable and connectors. At 450MHz, the 0.590"-diameter cable has 1.7dB/100 feet loss, compared to 2.3dB/100 feet for the ½"-diameter corrugated-copper cable.

The comparison is similar between the ¼"-diameter corrugated-copper cable and the 0.405"-diameter foil-braid cable. Loss at 450MHz is 2.7dB/100 feet for the 0.405" foil-braid cable, compared to 3.9dB for the ¼" corrugated-copper cable. Cost of materials for a 20-foot assembly is $35 for the foil-braid cable and connectors.

The development of the additional sizes of the new cables, including ⅞" diameter and 1¼" diameter, will provide additional choices in the selection of low-loss cables. These products have been introduced and are in field trials.

As technology has advanced, radio and antenna prices have decreased dramatically over the last few years, whereas the costs of low-loss cables have continued to escalate, and the cable technology has stalled. These new cables represent the first important advance in low-loss cables in more than 10 years. Cost-effective alternatives such as these will help to ensure the growth and the health of the mobile communications industry.

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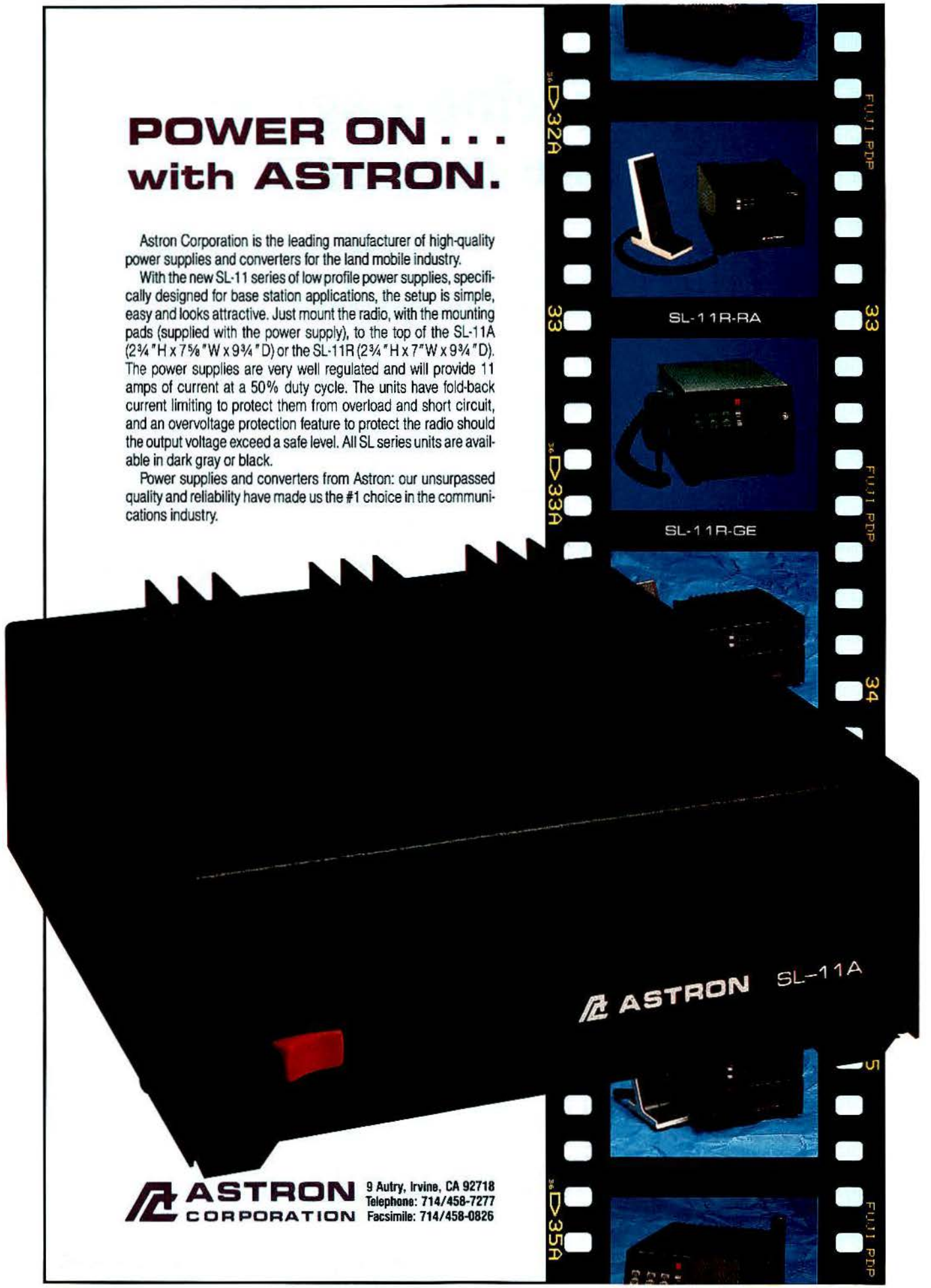

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Servicing pagers: The receivers

Part 5—Here are some tips for identifying which frequency bands correspond with which receiver boards in Bravo pagers to help you install the right boards for hooking up new customers.

By David Ludvigson

Motorola Bravo receivers have been designed for several frequency ranges.

Although these ranges include the range from 33MHz to 50MHz, this discussion covers pagers used at frequencies above 150MHz.

Quick identification

From the backside, there are few visible differences between most of the Bravo receiver boards—they are all the same size, they all fit the 8-pin connector, and they all do basically the same job.

Our task is to identify which receiver will work in any given portion of the spectrum allowed by our *frequency and function chart*. (See Part 3, March issue.) Again, Motorola has simplified the task.

Located on a sticker on the back side of the receiver module is a number. Refer to the following chart for frequency range.

FREQUENCY RANGE (MHz)	RECEIVER MODULE No.
929 – 932	NRF4071A-F
406 – 420	NRE6421A,B
450 – 465	NRE6423A,B
465 – 480	NRE6424A,B
480 – 495	NRE6425A,B
495 – 512	NRE6426A,B
450 – 465	AARE4001A-0
450 – 465	AARE4001A-1
465 – 480	AARE4002A-0
465 – 480	AARE4002A-1
138 – 143	NRD7211A,B
143 – 148.6	NRD7212A,B
148.6 – 152	NRD7213A,B
152 – 159	NRD7214A,B
159 – 164	NRD7215A,B
164 – 169	NRD7216A,B
169 – 174	NRD7217A,B

These receiver boards are interchangeable; thus, by merely replacing a 932MHz board with a 454MHz board, the pager is capable of operating in a different frequency band. *Certain caveats must be noted when trying to interchange Bravo Plus or Bravo Express boards in the simple Bravo. Specifically, they will not work. Pinouts on the 8-pin connector are incompatible.*

In passing, the second conversion oscillator in these receivers determines the *polarity* of the received POCSAG or Golay code. Depending on *high-side* or *low-side* signal injection (at the second mixer), the detector *flips* the output polarity of either code format in the same manner as detecting *one side* of a single-sideband signal.

This factor might require attention during the Bravo programming stage (SELECT JRB/C or BAB), but it is confirmed easily by the NORMAL/INVERTED position of a POCSAG-Golay generator.

Quick identification of the band of operating frequencies requires a look at the component side of the receiver board.

Ludvigson is a technician in Houston.

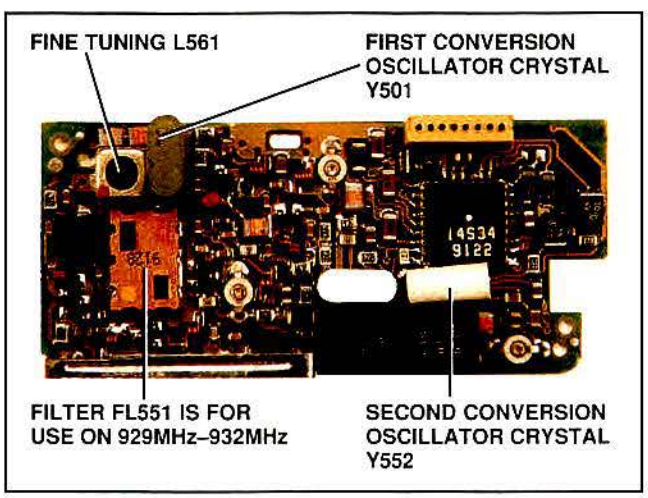

Photo 1. NRF series 929MHz–932MHz receiver circuit boards are easily identified by the small rectangular filter (FL551) used at the output of the RF pre-amplifier. Fine tuning is available by adjusting L561.

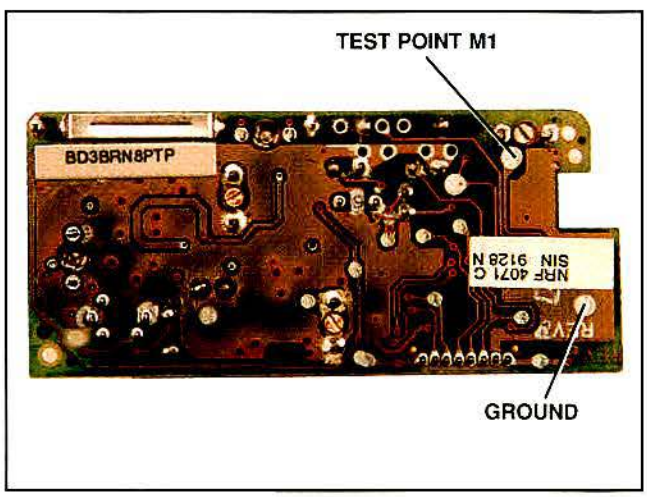

Photo 2. These are the M1 test point and ground locations on the NRF series 929MHz–932MHz receiver circuit boards.

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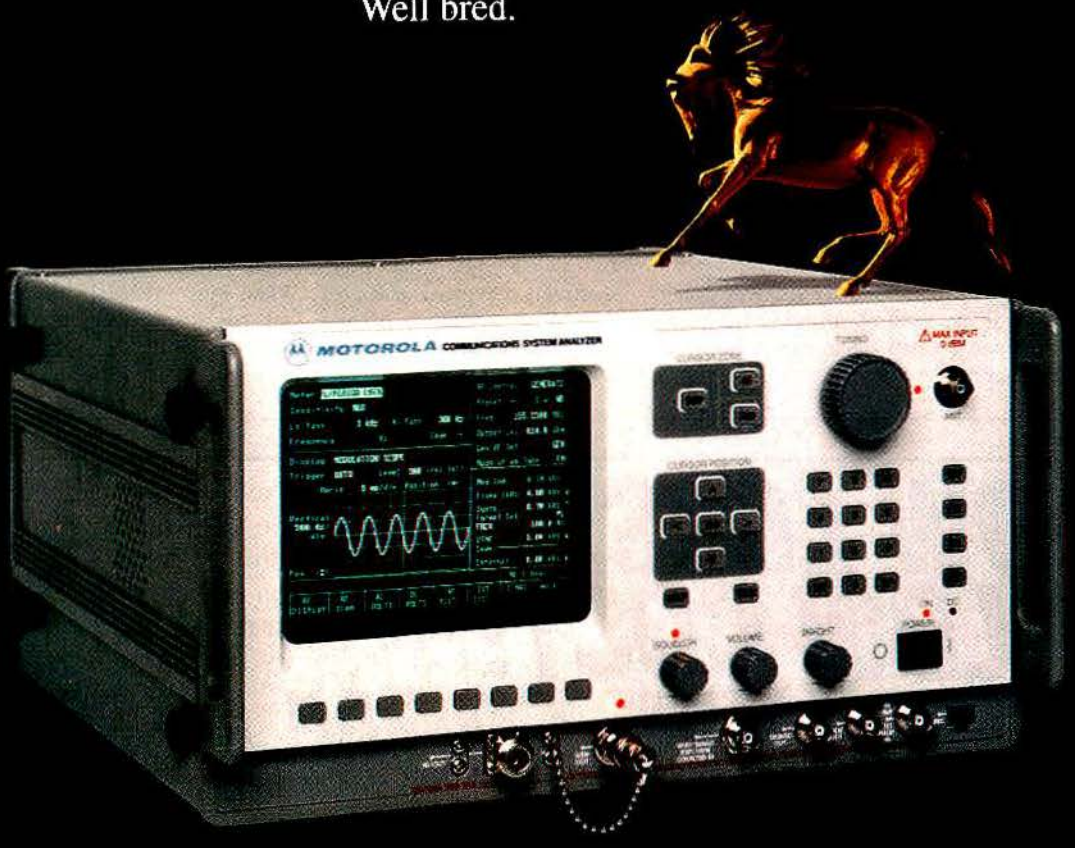

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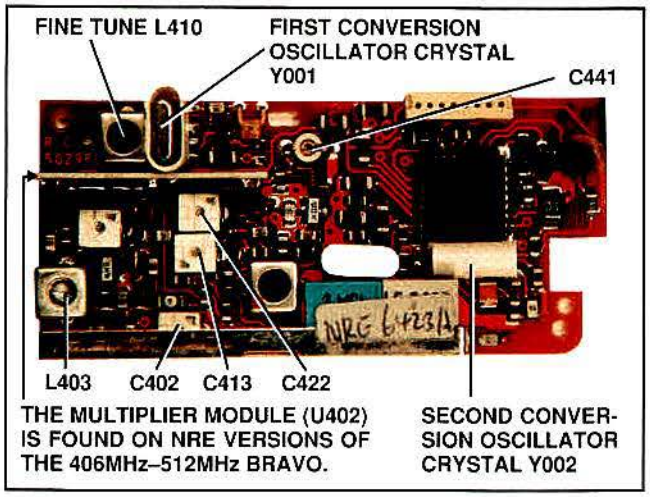

Photo 3. NRE series 406MHz–512MHz receiver circuit boards are identified simply by the ceramic module for the first conversion oscillator stage. Changing crystals requires adjusting both L410 and C441, and 'touch-ups' on C422, C413, L403, and C402. For small frequency changes, try adjusting only L403 and C402.

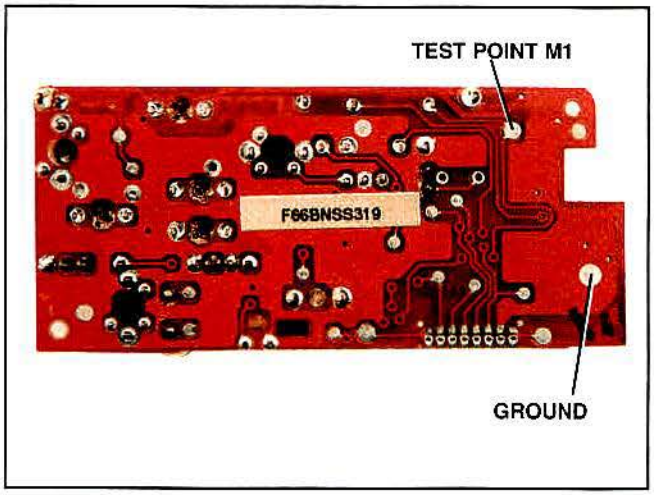

Photo 4. These are the M1 test point and ground locations on the NRE series 929MHz–932MHz receiver circuit boards.

Antenna and RF pre-amplifier filters tell the whole story.

The 928MHz–933MHz receiver usually has a single band of strapping for an antenna and a small square subassembly for a pre-amplifier filter.

For 406MHz–512MHz, the antenna may be either a single strap or a dual-strap (inductively coupled) assembly. When the dual-strap antenna is present, look for a ceramic sub-strated first conversion oscillator. This is a modular multiplier for the first conversion frequency.

Another version of the 406MHz–512MHz band receivers uses three tuning inductors as a helical filter between the RF pre-amplifier and the mixer. Wide frequency changes require both

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a re-alignment and a shielded room, such as the one described in Part 1, January issue, to optimize these inductors effectively.

Receivers equipped to run on 138MHz–174MHz are denoted by the use of a ferrite core surrounded by a single band of metal for an antenna loop. Beneath an identifying sticker are several capacitors placed in a notch across the metal band. The resonant circuit for this band is formed by the distributed capacitance, the values of these capacitors and the amount of inductance provided by the core.

Another significant clue to the frequency band is the placement of the first conversion oscillator crystal. It is placed parallel to, and at the edge of, the circuit board.

Receivers with a ferrite core with several windings of ribbon metal operate below 50MHz and will not be treated in these discussions.

Please note that tuning of these receivers will *require* a ceramic tuning tool. *Severe de-tuning results from the use of metal tools, such as jeweler's tools.*

NRF (929MHz–932MHz) receivers

The 929MHz–932MHz NRF series receiver circuit boards are identified easily by the small rectangular filter (FL551) used at the output of the RF pre-amplifier. (See Photo 1 on page 16.)

Located at one corner of the filter is the first oscillator crystal (Y501). Depending on the frequency of the first intermediate frequency, this crystal's frequency ranges between 73.666MHz and 76.175MHz. Fine tuning is available by adjusting L561.

The alignment of these receivers is straightforward. Radiate a signal into the RTL-1005 (You are in your shielded room, aren't you?) and test receiver sensitivity using M1 and ground. (See Photo 2 on page 16.) If necessary, adjust L561 to center the signal, and adjust the multiplier stage, the RF pre-amp and the second conversion oscillator frequency for optimum performance.

NRE (406MHz–512MHz) receivers

The 406MHz–512MHz NRE series receiver circuit boards are identified simply by the ceramic module for the first conversion oscillator stage. (See Photo 3 on page 18.)

Alignment can be really difficult without a shielded room because there are several LC networks in the RF pre-amp that interact. Changing crystals requires adjusting both L410 and C441, and "touch-ups" on C422, C413, L403 and C402. For small frequency changes, I suggest adjusting only L403 and C402.

Photo 4 on page 18 shows the M1 test point and ground locations.

AARE (406MHz–512MHz) receivers

AARE4001A receiver circuit boards cover the range of 450MHz–465MHz and

Pager servicing series

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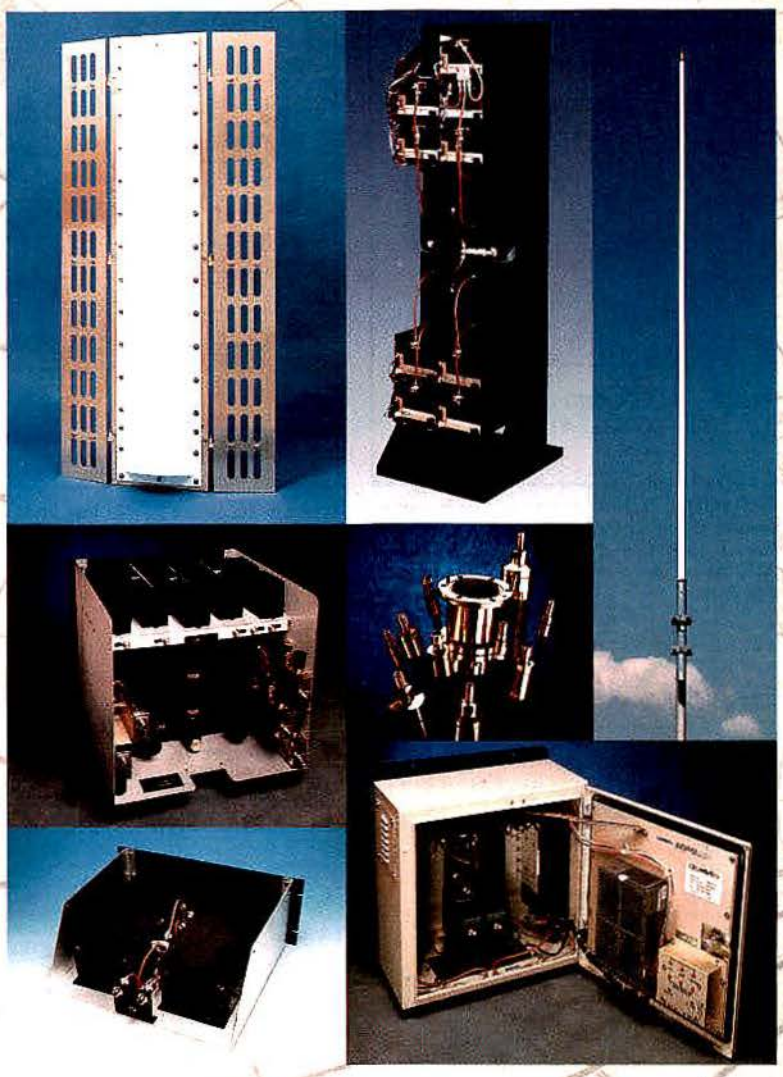

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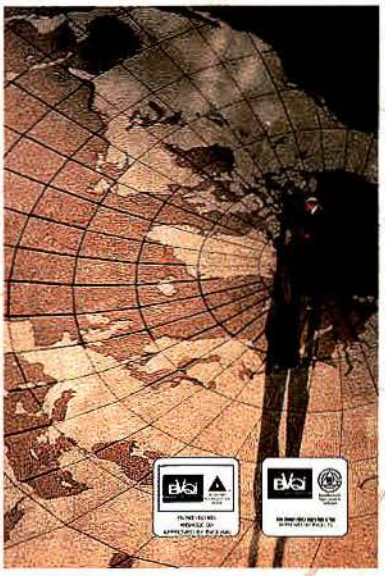

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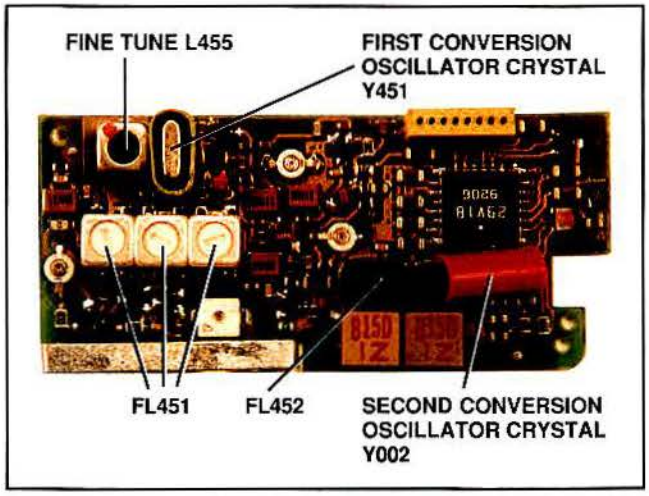


Photo 5. AARE series 406MHz–512MHz receiver circuit boards are virtually identical, with the exception of the tuning range. The AARE4001A board (pictured) covers 450MHz–465MHz and contains a 3-bay helical filter (FL451). Note that Y002 is the second conversion oscillator crystal. FL452 serves as a band-pass filter.

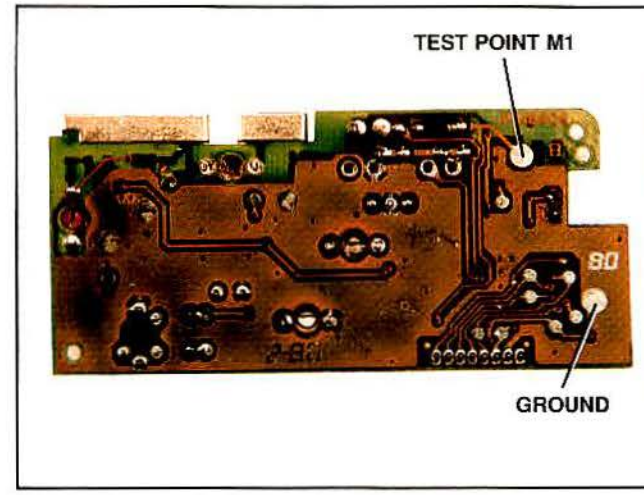


Photo 6. These are the M1 test point and ground locations on the AARE series 406MHz–512MHz receiver circuit boards.

contain a three-bay helical filter (FL451). (See Photo 5 above left.)

The AARE series pagers virtually are identical, with the exception of the tuning range. Further, note that Y002 is the second conversion oscillator crystal.

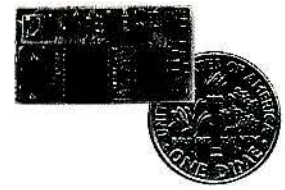
FL452 serves as a band-pass filter.

Photo 6 above right shows the M1 test point and ground locations.

NRD (138MHz–174MHz) receivers

As shown in Photo 7 on page 26, NRD series receiver circuit boards use a ferrite bar in the antenna circuit.

The first conversion oscillator crystal, Y001, is in the range of 40.00MHz to 65.3MHz, followed by a frequency multiplier. The second conversion oscillator



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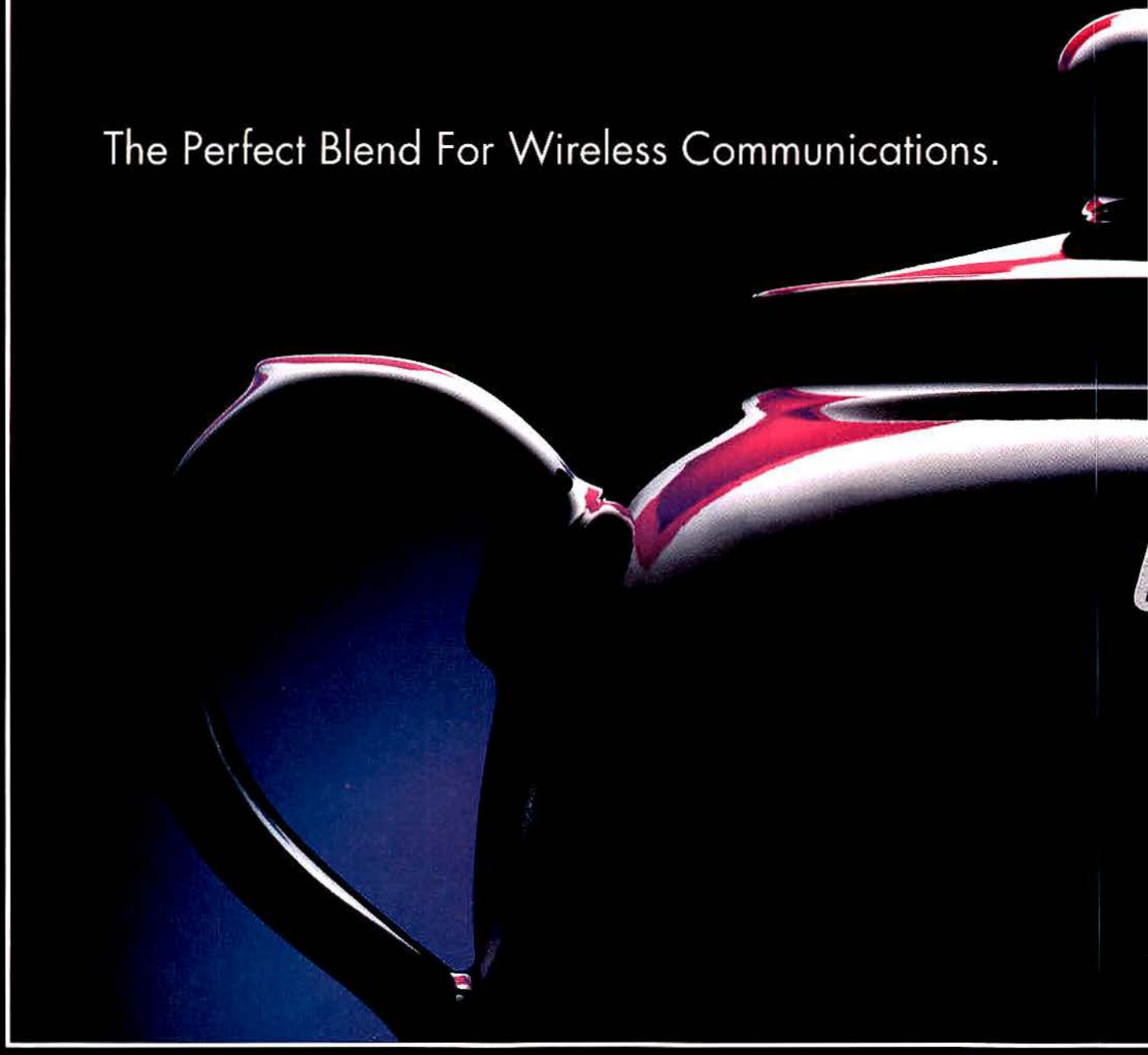

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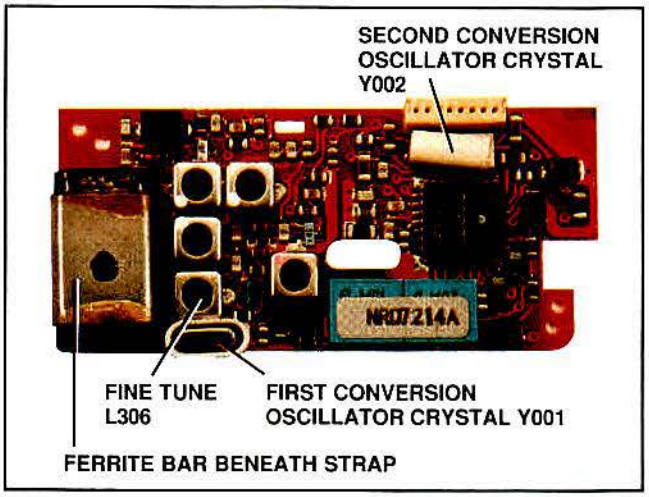


Photo 7. NRD series 138MHz–174MHz receiver circuit boards use a ferrite bar in the antenna circuit.

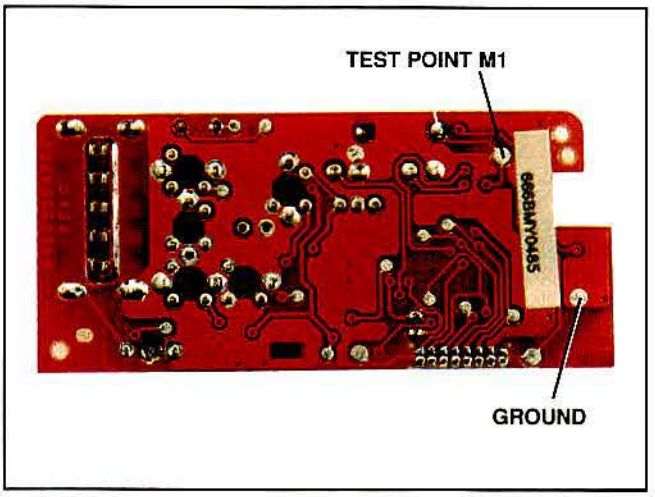


Photo 8. These are the M1 test point and ground locations on the NRD series 138MHz–174MHz receiver circuit boards.

(Y002) is set either +455kHz or −455kHz from 17.9MHz. As mentioned earlier, this frequency choice affects the polarity of the decoded signal.

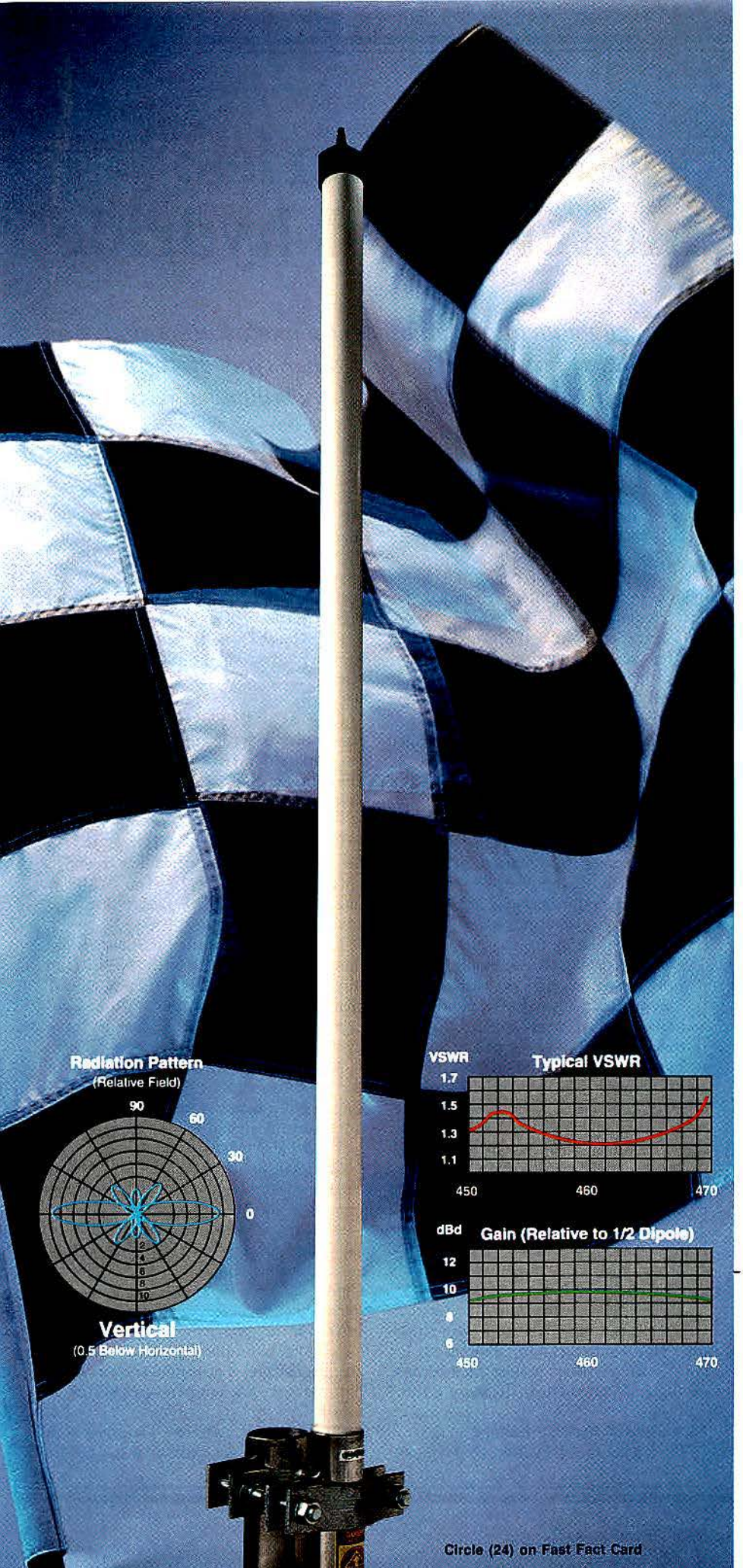
L305 varies the signal input from the multiplier into the first mixer. L306 tunes the crystal (Y001) to frequency. L302 and L303 adjust the RF pre-amplifier to resonance while L304 is broadly resonant at 17.9MHz. A future article describes these circuits in detail.

Photo 8 above right shows the M1 test point and ground locations.

Motorola, from the start, has designed the Bravo receivers around triple-conversion superhets. Although the costs and complications of this conversion scheme have their drawbacks, the unrivaled sensitivity and selectivity this circuit affords cannot be denied.

Acknowledgement

I would like to thank J.H. Kim, owner of JJ Sounds, South Houston, TX, and co-workers Raymond, Tim and Pete, for their help with this project.



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Rechargeable batteries: NiCd and nickel-metal hydride

Part 1—More portable radio communications equipment manufacturers and users select nickel-cadmium (NiCd) batteries than any other type. Here are some comparisons between NiCd technology and a challenger.

By Isidor Buchmann

One of the common difficulties with battery-powered equipment is the gradual deterioration in performance after the first year of service.

Although fully charged, the battery's performance may have dropped to half the original capacity, resulting in unexpected down time. Without knowing the reason for the failure, the user sends in the equipment for service, only to find out that the problem has not been solved. Service centers have indicated that half of the equipment failures are battery-related.

The battery is the mystical "black box" that causes much grief, frustration and headache. One never knows whether the battery is fully charged or empty.

Has it taken a full charge, or has the *ready* indicator on the charger fooled the user, only to have the battery quit after 30 minutes of use? The battery does not reveal its mood; it does not change weight, color or shape to indicate its status. It simply keeps the user guessing.

In many ways the battery exhibits human-like characteristics: it needs good nutrition; it likes a moderate room temperature; and, in the case of the nickel-cadmium (NiCd) battery, it requires regular exercise. This article focuses on the needs of the different battery chemistries, what applications are suitable for them and how one can get the most out of them.

Nickel-cadmium battery

Among the rechargeable batteries, the NiCd remains the most popular choice. Some of its distinct advantages over other battery chemistries are:

(1) fast and simple charge.

(2) high number of charge-discharge cycles. (When properly maintained, the NiCd provides several thousand cycles.)

(3) excellent load performance, even at cold temperatures.

(4) simple storage and transportation. (The NiCd is accepted by most air freight companies.)

(5) easy to recharge after prolonged storage.

(6) forgiving if abused.

The NiCd is the tough and silent guy. Hard work poses no problem. It prefers fast-charge over trickle-charge and pulse-charge over dc charge.

Improved performance is achieved by interspersing discharge pulses between charge pulses during the charging process. This charge method is commonly referred to as *reflex* or *reverse load* charge.

The brief discharge currents promote the recombination of gases generated during fast-charge. This type of charge method results in a cooler and more effective charge than can be obtained with conventional dc chargers. A study done by a German battery manufacturer has shown that the reverse load charge method adds 15% to the life of the NiCd battery.

The NiCd does not like to be pampered by sitting in chargers for days and being used only occasionally for brief periods. In fact, the NiCd is the only battery type that performs best if periodically fully discharged.

All other battery chemistries prefer shallow discharges. So important is this periodic full-discharge that, if omitted, the NiCd gradually loses performance because of voltage depression or "memory effect."

Nickel-metal hydride battery

The nickel-metal hydride (NiMH) battery has been heralded as the shining star that will solve the battery problems of the 20th century and lead us into the 21st.

Although some of the claims are over-optimistic, the NiMH has distinct advantages over the NiCd.

(1) The NiMH is not affected by memory effect in the same way as the NiCd. Periodic exercise cycles may not be necessary.

(2) The NiMH provides 30% more capacity over a "standard" NiCd.

(3) The NiMH is environmentally friendly because it contains no toxic metals.

Unfortunately, the NiMH lags behind the NiCd in several aspects. For example:

(1) *Number of cycles*—The NiMH is rated for only 400 to 700 charge-discharge cycles.

It does not like to flex its muscles too hard, and the longevity of the NiMH is in direct relationship to the depth of discharge. In comparison, the NiCd can accept several thousand full discharge-charge cycles.

A GE research lab claimed that some of the NiCd batteries tested exceeded 30,000 cycles. NiCd batteries for satellite applications were designed to last for 17 years and provide 70,000 cycles.

(2) *Ease of fast-charge*—The NiMH battery does not lend itself to fast-charge as well as the NiCd.

Although a NiCd can safely be charged in 90 minutes, the NiMH will need about twice that time under the same conditions. Unlike the NiCd, the NiMH does not produce a dependable negative delta V to detect the full-charge.

A more complex algorithm for full-charge detection is needed to charge NiMH batteries if no temperature sensor is available.

(3) *Discharge current*—The maximum allowable discharge current of the NiMH

Buchmann is the founder and chief executive officer of Cadex Electronics in Burnaby, British Columbia. He has been active in the radio communications sector and has studied the behavior of NiCd batteries in practical, everyday applications.

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is considerably less than that of the NiCd.

Some manufacturers recommend a discharge current of 0.2C (one-fifth of the rated capacity). This shortcoming may not be critical for applications requiring only a small load, such as cellular phones. For high-power transceivers and power tools, for example, the more rugged NiCd is the recommended choice.

(4) *High self-discharge*—Both NiMH and NiCd are affected by self-discharge. The NiCd loses about 10% of its capacity within the first 24 hours, after which the self-discharge settles to about 10% per month.

For the NiMH, the self-discharge is higher as the hydrogen atoms try to escape. Selecting materials that improve bonding of the hydrogen reduces the capacity of the battery. Research engineers are faced with a compromise between an acceptable charge retention and high capacity.

(5) *Capacity*—Even though the NiMH delivers 30% more capacity than the standard NiCd, ultra-high-capacity NiCd cells now provide capacity levels similar to those of the NiMH. Tests performed by my company have shown good results with the new foam matrix NiCd cells by Panasonic. Sanyo is introducing the new *pasted* NiCd cell that is said to have similar performance to Panasonic's foam cell.

One should be aware, nonetheless, that there are compromises in increasing the capacity of the NiCd.

To obtain higher energy, more active material is packed into the cell. As a result, the internal resistance increases, which in turn reduces the maximum charge and discharge currents. The ultra-high-capacity cell tends to warm up more during fast-charge and discharge than the standard NiCd.

(6) *Stability*—Tests by my company have shown significant variations in performance between different brands of NiMH batteries.

These variations may be due to the metals used. Some NiMH batteries are based on early technologies using metal alloys such as titanium, zirconium, vanadium, nickel and chromium. Some Japanese companies are experimenting with other metals, such as the rare lanthanum.

We have had good test results with the Japanese prismatic NiMH cell used by NTT for a line of cellular phones. Stable results also have been achieved with the Motorola NiMH replacement batteries.

On the other hand, another brand of NiMH cells from the Pacific Rim does not offer the same performance.

(7) *Price*—The price of the NiMH is about 50% higher than that of the NiCd.

Price may not be a big issue when the customer requires high capacity and small size. Panasonic's foam NiCd batteries are only slightly higher-priced than the standard NiCd cells. This means that capacity-for-capacity, the foam NiCd is more competitively priced than the NiMH.

Organizations such as the military, Bell Lab and Black & Decker have made comments that NiMH chemistry is not yet fully defined. The NiMH is not new. In the '70s, this battery chemistry was tested and consequently dropped because it was considered unsuitable for the applications intended. The modern NiMH has improved and likely will maintain a strong market niche, especially in the cellular phone market.

Next: Lead-acid and lithium batteries; memory effect and self-discharge; and battery conditioning.

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What technicians should know about fiber-optic installation

Part 2—Skills with fiber-optics help technicians to service a broader range of communications installations. Here is some helpful information about cable specifications, splices, connectors and power budgets.

Wayne R. Gipson, C.E.T.

Fiber-optic technology supports information transfer that is at once fast, efficient, cost-effective, reliable and, most of all, accurate.

Fiber-optic transmission projects a light source through a clear *coax* of glass or plastic to a receiver. The transmission is immune to noise and interference that might disrupt signals carried by radio or wire.

The center of the fiber cross-section—the *core area*—conducts light, whereas the outer area—the *cladding*, is altered by chemical deposits during manufacture so that light straying from the core area reflects back to the core and along the length of the fiber to its destination.

There are two types of fiber, *single mode* and *multimode*. In fiber-optic terminology, *mode* refers to the number of paths the light may travel.

Multimode fiber is used with light-emitting diode (LED) transmitters that are inexpensive, but its multiple paths eventually limit the fiber's bandwidth because the varying paths eventually degrade the light pulses so much that errors result. Single-mode fibers use lasers for transmitters. Laser light is coherent, meaning that, theoretically, the light energy travels in one path. A lack of divergent wavelengths means that the signal can be sent without light pulse degradation.

Fiber must be sheathed for protection. Fiber cables generally are characterized as loose-buffered or tight-buffered. Tight-buffered cable is coated with plastic that increases its diameter to about 900 micrometers. The coating usually is color-coded for easy identification.

Connectors generally can be applied to plastic-coated fiber without further protection, provided that the fiber, once installed, is not disturbed.

Loose-buffered fiber is delivered with coating only 250 micrometers thick, and it, too, generally is color-coded.

Fibers in a cable may be placed in tubes wrapped around a central member that provides some protection against bending the cable in such a small radius that the fibers are damaged. Alternatively, the fibers may be delivered in a hollow, stiff tube. (See Photo 1 to the left.)

Ribbon fibers, which are bundled together by polyester tape, deliver a high fiber count with as many as 144 fibers per cable.

Loose-buffered fiber is placed in gel-filled tubes.

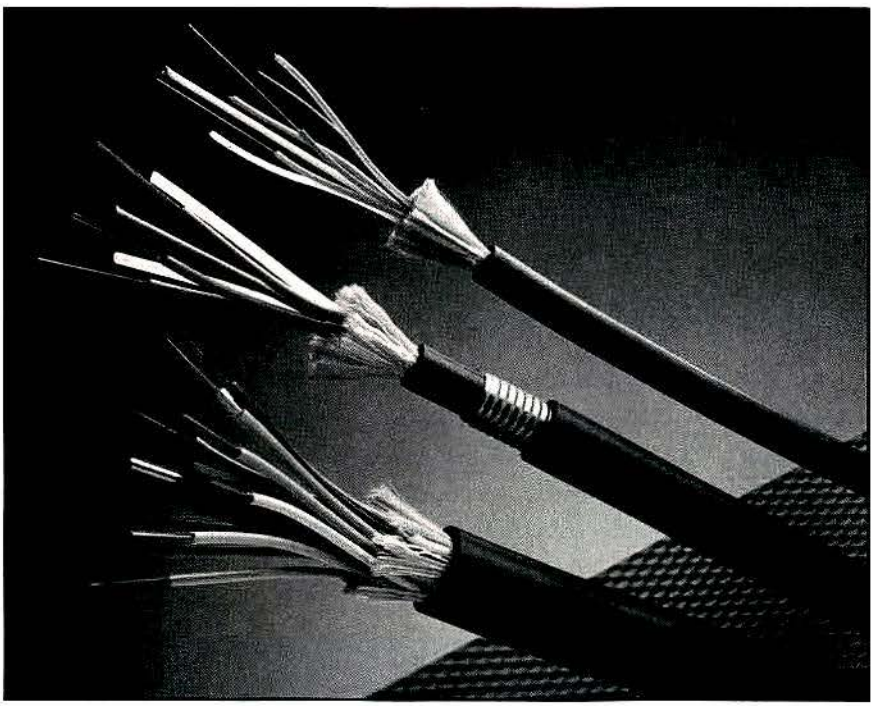

Photo 1. These are examples of loose-buffered, outside plant cables. The top cable has a dielectric central member and loose tubes with low fiber counts that wrap around the central member. The middle cable is a rodent-proof, armored underground fiber. The bottom cable is a high fiber count outside cable with a metal central member.

Specifying cable

Outside plant cables that are subject to temperature extremes, such as aerial and buried cables, all use loose-buffered cable.

Gipson is a senior communications technician with experience in fiber-optic specification, installation, splicing and connectorization. He has an FCC General Radiotelephone Operator license and an ISCET certified electronics technician certificate. He lives in Wichita, KS, where he works for Western Resources, a utility company.

Siecor, Hickory, NC, provided the photographs used in this article.

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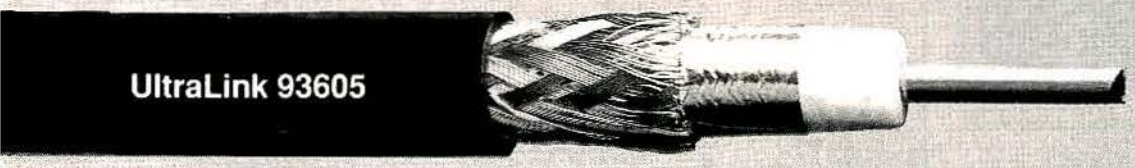

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Photo 2. An optical time domain reflectometer.

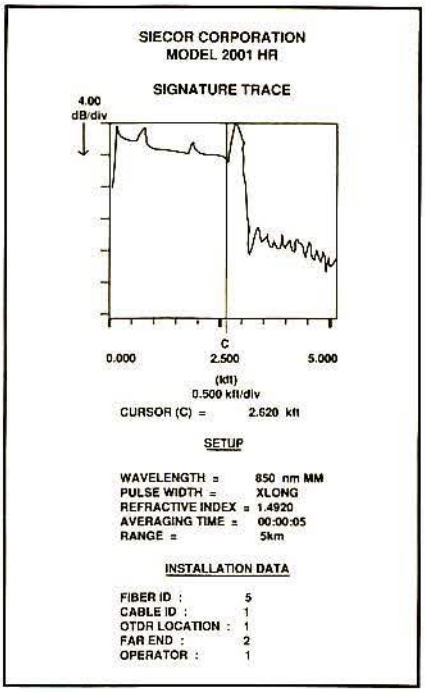


Figure 1. This printout shows the time domain reflectometer setup conditions that affect the readings. The instrument can be adjusted to move the cursor to any point on the graph to identify cable length on the trace. Note the *refractive index* that varies with each manufacturer and type of fiber. The center spike has no effect on the slope of the line; therefore, it represents little loss compared to the ramp on the first splice. This measurement was made with a 2,620-foot fiber.

If outside fiber were tight-buffered, extreme temperatures that cause the glass and plastic coating to contract and expand at different rates would place stress upon the fiber and cause damage.

Fibers loosely "floating" in the loose-buffered cable's hollow tube can expand and contract without damage. The gel filling allows for this variance in length while keeping water from entering the cable and causing damage when it freezes.

Outside plant cable is manufactured in various ways, depending on the placement.

If the cable is to be buried, then a metallic sheath is placed under the outside covering. This sheath prevents rodents from chewing into the fiber.

If the fiber is to be placed on poles, then a *messenger* or support cable might be molded into the coating, or the fiber might be *lashed* onto an existing line.

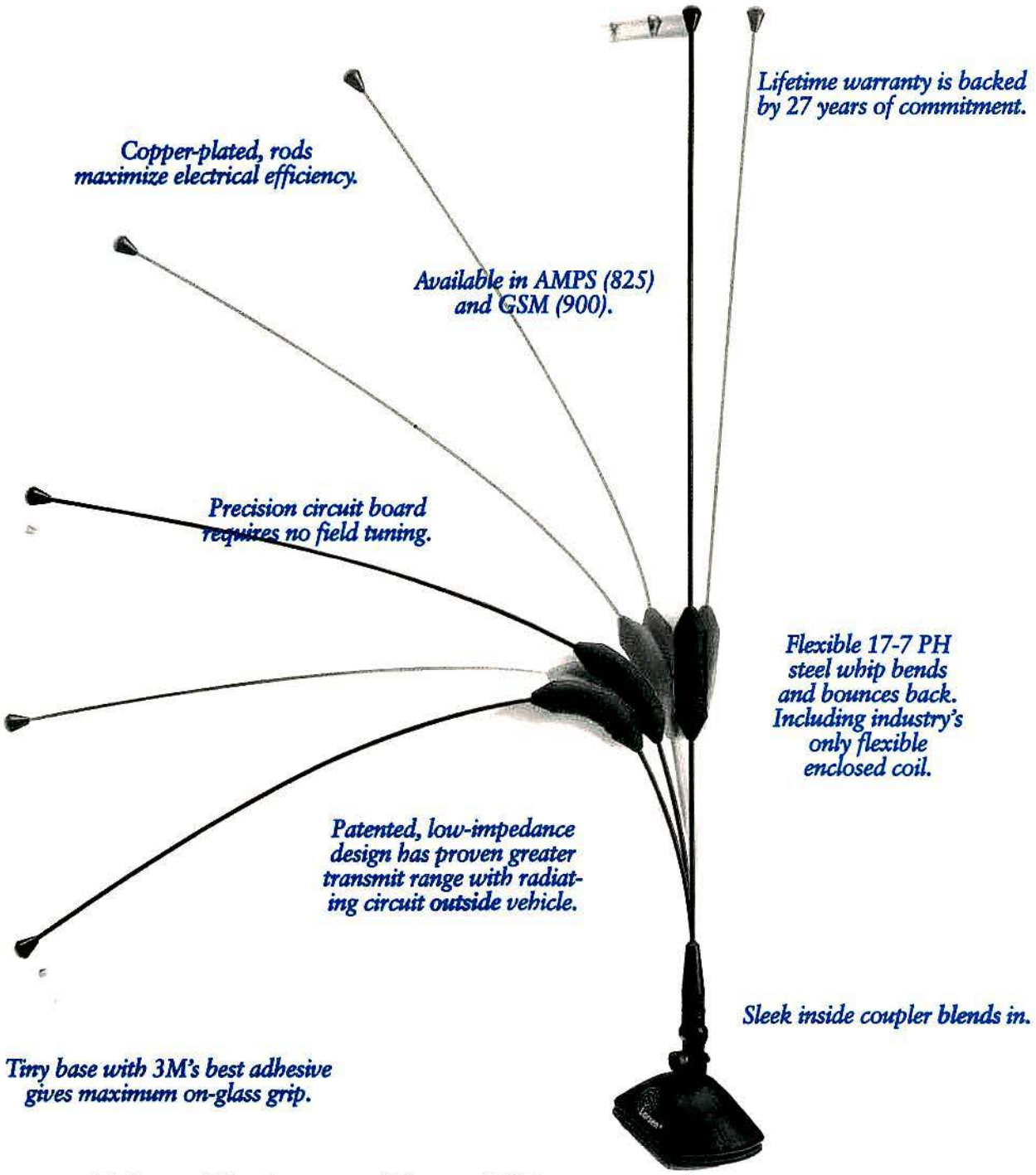
If electrical isolation or lightning protection is desired, then the cable might be constructed entirely of dielectric materials.

Fiber is susceptible to damage when unprotected, but it proves to be extremely robust when used in cables. If cable is not installed properly, though, signal transfer efficiency is affected.

Fiber losses

Losses in fiber can be categorized as *intrinsic* and *extrinsic*.

Intrinsic losses are caused by impurities in the fiber, such as water, and they are beyond the installer's control. These impurities absorb or deflect light into the



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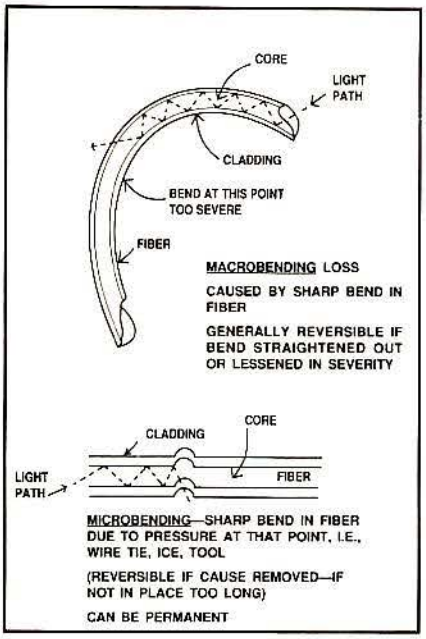

Figure 2. Bends cause *extrinsic losses*. Both types of bends, macrobending and microbending, generally are reversible if they are found and corrected soon after installation.

cladding. Reflection of energy caused by impurities may be analyzed with an *optical time-domain reflectometer* (OTDR). (See Photo 2 on page 34.)

An OTDR sends a laser signal into a fiber and then measures reflected energy caused by fiber impurities to draw a graph indicating line loss and whether the loss is in the fiber itself or whether it is caused by splices and connectors.

Macrobending results when the fiber is bent past an angle at which the light follows the glass path, entering the cladding instead.

Note that cable loss is measured in decibels. In fiber optics, the decibel is referenced to 1 milliwatt.

For example, a loss of −3dBm equals 500 microwatts, and +3dBm equals 2 milliwatts.

In the signature trace in Figure 1 on page 34, the *x axis* shows the fiber length, and the *y axis* indicates relative losses in decibels. Spikes along the path indicate splices.

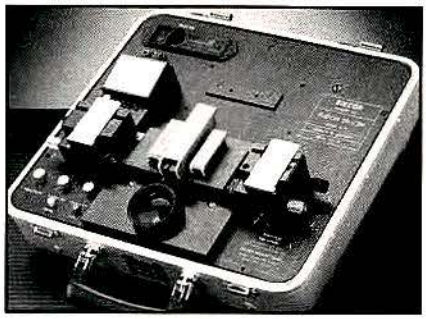

Photo 3. Notice the light injection-detection (LID) meter on the left side of this fusion splicer. Fiber to be spliced is bent, and a light is sent through the splice from the first fiber to the second, which also is bent to allow light to be measured. When the fiber is fused, the meter indicates the splice quality based on the amount of light it passes.

Extrinsic losses are caused by bends.

Macrobending results when the fiber is bent past an angle at which the light follows the glass path, entering the cladding instead. (See Figure 2 to the left.)

Microbending occurs when a straight run of fiber is bent by ice crystals, or when tie wraps that secure the fiber are pulled

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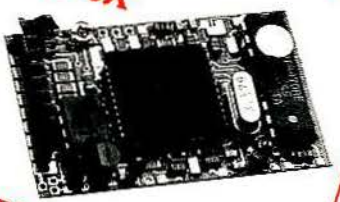

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- Forced decode reset
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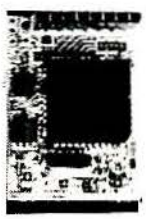

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too tightly, creating indentations in the path.

Both macrobending and microbending generally are reversible if they are found and corrected soon after installation.

Splicing

Long fiber cable runs require splicing. There are two types of splices, *fusion* and *mechanical*.

Fusion splicing involves precision-melting and fusing the fiber ends together. (See Photo 3 on page 36.)

The ends of the fibers to be connected first are cleaved to make the ends perpendicular and then fastened into the splicer where they are aligned under a microscope. Once they are positioned correctly, an arc is applied to the joint. If all goes well, the fiber melts together, and the core and cladding areas provide a low reflection throughput for light to pass.

To mechanically splice a fiber, the ends are cleaved in the same fashion as the fusion splice, and then the fibers are placed in a sleeve of some sort (there are many types), and positioned to touch each other. (See Photo 4 below.)

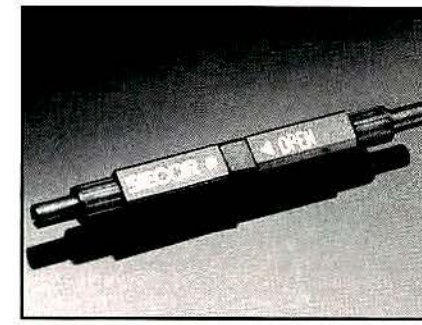

Photo 4. With a mechanical splice, fibers are cleaved and inserted into each end of the splice. The splice unit tightens over the two fibers, making the splice secure. Index gel inside the splice helps to keep loss to a minimum.

Inside the splice sleeve, index-matching gel is applied to ensure that the cleaved ends are surrounded by a substance that treats lights similar to the way glass does. If air comes between the fiber ends, loss results.

Once the fibers are placed correctly, the splice is manipulated to secure the fibers mechanically, or if the splice is filled with epoxy, it is cured to provide a permanent bond. For most applications, mechanical splices provide results similar to fusion splicing and are widely used.

Referring to the signature trace, the two spikes are reflections made by the ends of the fibers in a mechanical splice.

In wideband applications, such as in cable television, reflections are undesirable because they reduce power output. In such applications, reflections cause the feedback circuits controlling the laser output to reduce because the circuits count both the forward and unwanted reflected power as emitted output.

For most data applications, mechanical splices serve well.

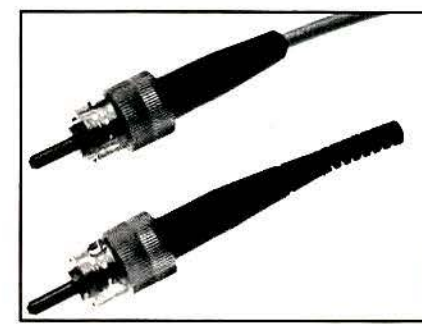

Photo 5. ST-type connectors. The lower connector is attached directly to a 900-micrometer tight-buffered cable.

ATTENTION

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Tampering with Motorola's communication software is nothing short of a crime.

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Theft and unauthorized copying of Motorola communications radio software is illegal.

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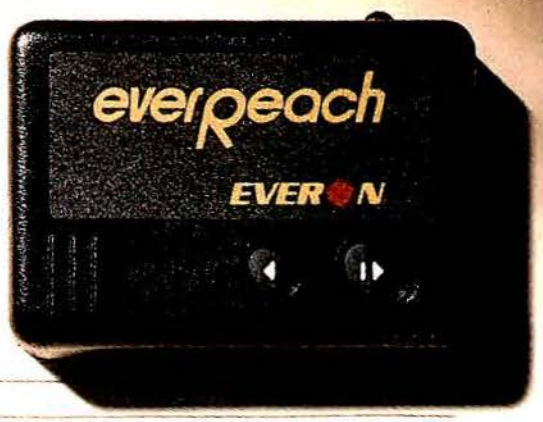
RESUME



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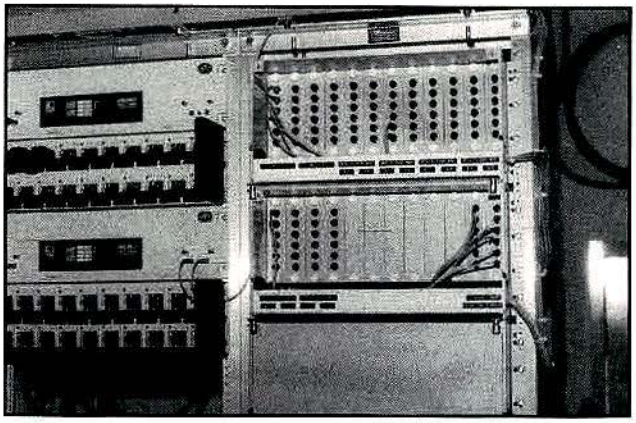

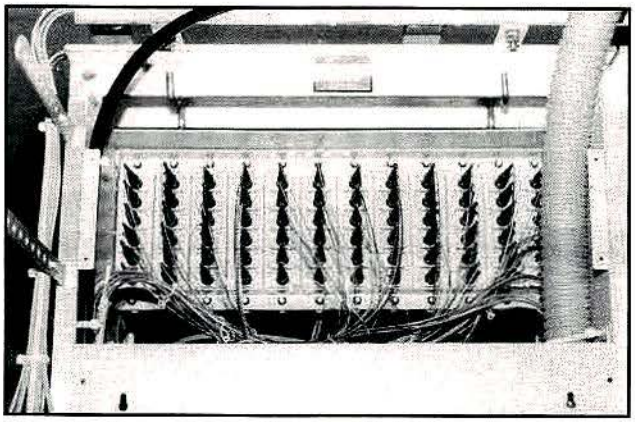

Photo 6. These are front and rear views of a fiber distribution center. From this center, fibers extend to all areas of the building.

Once spliced and delivered to the premises, the ends of the fiber must be prepared to meet the equipment intended for use with optical communications.

Outside plant cable generally is brought no more than 50 feet into a building before it is spliced to fiber appropriately sheathed for inside applications. The inside fiber is routed to an interconnect box, which is then patched to the end-user equipment.

Connectors

A variety of connectors are on the market, and in some cases, choices are made by end-equipment vendors. In most cases, the ST connector is used for multimode cable. (See Photo 5 on page 38.)

ST connectors are made up either to 900-micrometer tight-buffered cable or to fibers inserted in *fan-out tubes* to protect the fiber ends.

Many fibers can be brought to a central point to connect with any destination within a building requiring distribution. (See Photo 6 above.)

Power budget

When designing the fiber path, the engineer takes into account losses inherent in the fiber construction process. In figuring a power budget, high-quality $^{62.5}/_{125}$ fiber generally is rated at 3.75dB loss per kilometer when tested with a source emitting 850 nanometer-wavelength infrared light.

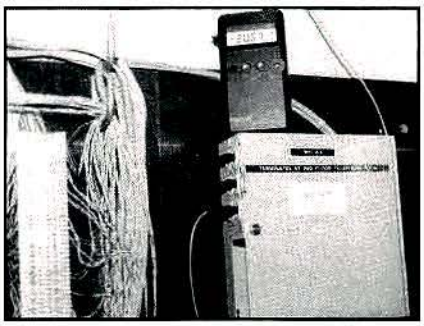

Photo 7. This power meter measures light in a fiber and reads output in decibels referenced to 1 milliwatt (dBm).

Each splice is assigned a loss of 0.5dB, although splice losses generally are as low as 0.2dB, and each connector pair is assigned a loss of 0.5dB. When the path is tested, a light source is attached to one end, and a calibrated light meter is connected to the other to read path loss. (See Photo 7 to the left.)

When fiber is properly installed, its loss generally is much less than the power budget predicts.

Technology has progressed to a point where a single fiber can carry more than 24,000 telephone conversations simultaneously. With fiber, data processing using a central database becomes tremendously faster.

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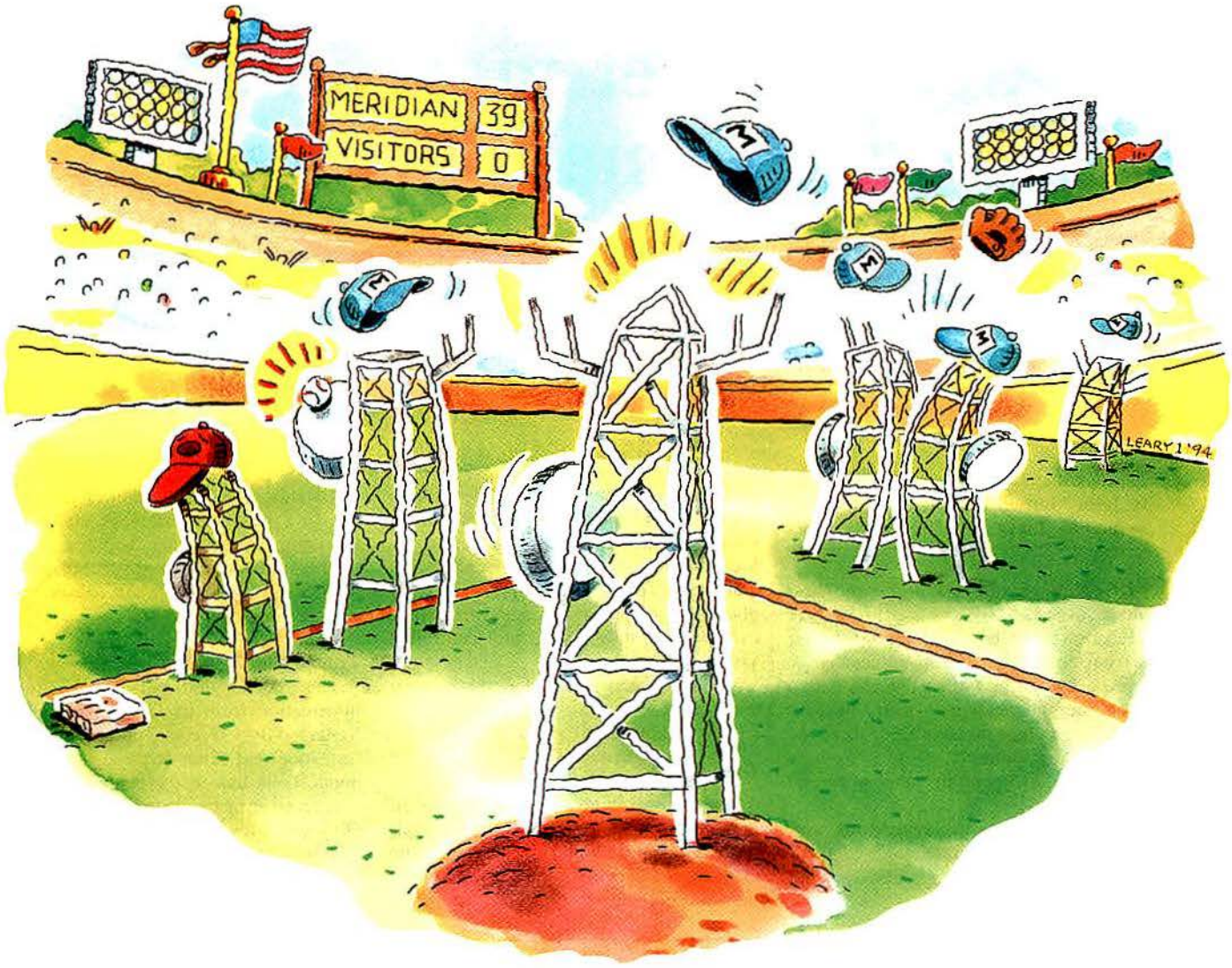

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Circle (37) on Fast Fact Card

Track fleet movements with a PC mapping system

A flexible personal computer mapping system uses advanced vehicle locating and tracking technologies to form an integrated automatic vehicle location system designed for accurately tracking fleet movement.

By John Mansell, Pat Friend and Jacqueline Jones

Dispatching vehicles along the best routes saves time.

Fleet owners who use vehicles for their own businesses benefit from reduced costs. Those costs can be further reduced with a private communications system, because once the purchase is amortized, there are no recurring monthly charges beyond the expense of operating employees and maintenance.

Fleet owners who use vehicles to carry goods for hire can become more competitive through reduced costs and speedier service.

An integrated automatic vehicle location (AVL) system allows fleet owners to track fleet movement accurately. Advanced vehicle locating and tracking technologies combined with a flexible personal computer (PC) mapping system give the fleet owner a privately owned and controlled system.

The integrated system has three major components:

- a tracking unit.
- a control center.
- a communications link.

The control center is a computerized mapping and monitoring station for all vehicles equipped with a tracking unit. The tracking unit provides vehicle identification, location, speed, direction, date, time and status. The information is processed and forwarded to a mapping controller in the control center that displays vehicle information on a digitized street map. This map allows a dispatcher to see each vehicle's location and status.

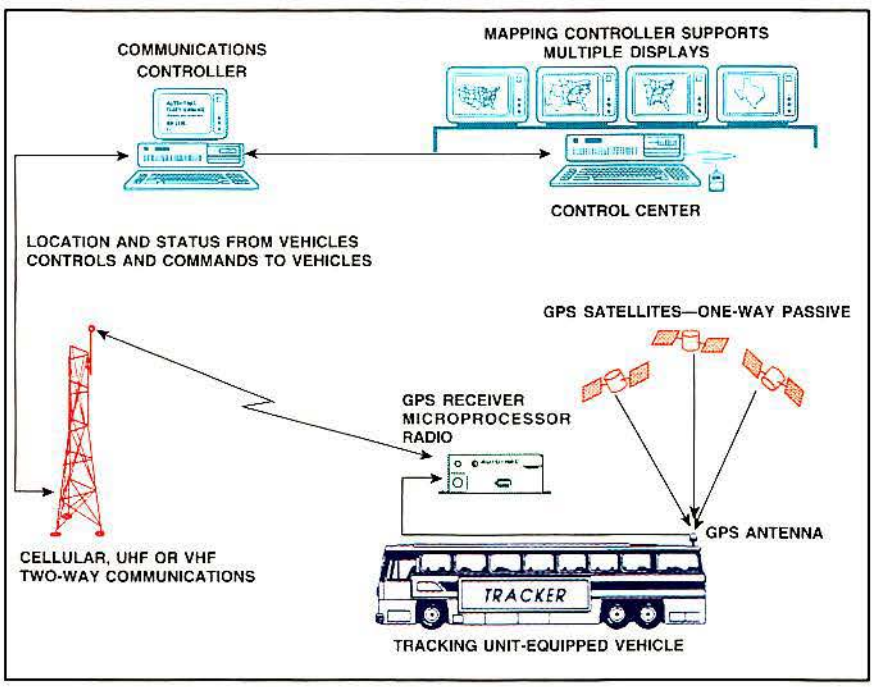

Figure 1. The Auto-Trac Fleetservice System provides complete automatic vehicle location (AVL). The three major components are a tracking unit, control center and communications link.

Tracking unit

The tracking unit gathers navigational information from its Global Positioning System (GPS) receiver, processes the information and sends it through the communications link to the control center.

A receiver that gathers information from GPS satellites determines the location. GPS satellites provide worldwide navigation information 24 hours a day. The GPS receiver calculates the tracking unit's latitude, longitude, speed and direction on a second-by-second basis.

Location information can be transmitted in any one of four modes:

▶ *Periodic* — Sends vehicle locations on a timed interval during normal operation.

▶ *Continuous* — Tracks the vehicle more closely by sending locations at a shorter interval at the request of either the vehicle operator or dispatcher.

▶ *On request* — Sends the vehicle location once at the request of either a vehicle operator or dispatcher.

▶ *By exception* — Sends the vehicle location based on specific events, such as when the vehicle is speeding, is outside a specific geographic area, or is stationary for an extended period.

The tracking unit has multiple RS-232 ports that allow the user to attach peripheral devices, such as a radio modem, a mobile data terminal (MDT), a printer (for text communication) or a dead-reckoning navigation device.

Mansell is president, Friend is director of sales, and Jones is marketing manager of Auto-Trac, Dallas.

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The tracking unit also can monitor and control switches. Monitoring can be as elaborate as the application requires. Input switches can be used to detect and report vehicle operations, such as tractor-trailer uncoupling, theft alarms and panic notification.

Control center

The control center handles all information received from the tracking unit. It maps vehicle locations, controls data communications to and from the tracking unit and performs functions such as data security, record-logging and database management.

The control center is a computer complex consisting of two high-speed PCs, five high-resolution monitors, a base station GPS receiver, modems, a printer and software.

▶ *Communications controller* — The communications controller manages all communications to and from the vehicle, controls the base station GPS reference receiver and routes vehicle locations, speeds, bearings and status to the mapping controller. It manages data messages to and from vehicles and simultaneously monitors any combination of eight telephone lines or base station radio controllers. Communications are initiated either by the tracking unit or by the communications controller.

Information received from the tracking unit includes vehicle identification, status, speed, heading, latitude, longitude, date, time and which satellites are being used. Status switches, such as alarms, warnings and trailer disconnections, are received when applicable. A status message can be a predetermined message initiated from a keypad (such as "en route" or "at site") or a text message from an MDT.

The operator can set the tracking unit's automatic reporting intervals to as frequent as one per second. The communications controller can send data messages to a mobile data terminal attached to the tracking unit. Using differential GPS, real-time GPS data received by the base station GPS unit can substantially improve vehicle location accuracy. The controller also monitors GPS status and displays an illustration

Two-way radio and cellular tracking units

Tracking units fit vehicles equipped with either two-way radios or cellular telephones.

▶ *Two-way radio* — For vehicles with two-way radios, the tracking unit includes a Global Positioning System (GPS) receiver, a GPS antenna, a microprocessor and controlling software. The unit, connected to a radio modem and the two-way radio, transmits vehicle locations to a central site.

The unit receives signals from three or more GPS satellites to calculate its latitude, longitude, speed and heading. It uses the results to make operational decisions. The processed message then can be sent to the control center or to a mobile data terminal.

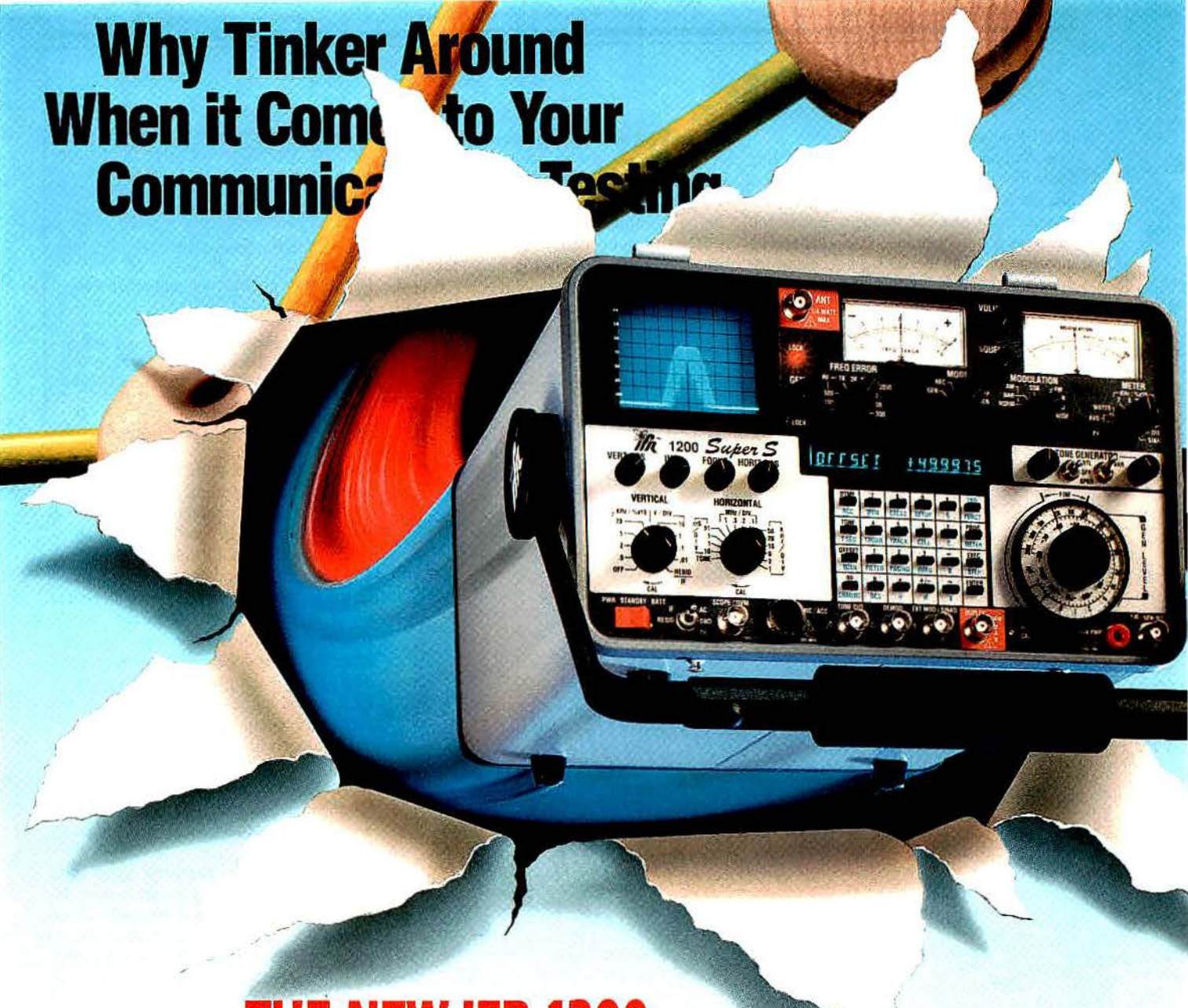
The tracking unit has multiple RS-232 ports, one for the radio modem, one for a mobile data terminal and one for a dead-reckoning navigation device or any other special peripheral. Four input switches allow monitoring of vehicle operations (such as an alarm or light bar activation), and four outputs allow functions to be activated or deactivated (such as an "engine kill" switch).

▶ *Cellular* — Whereas the two-way radio tracking unit normally connects with an existing radio or a newly installed radio of the customer's choice, the cellular tracking unit comes with a cellular transceiver. In addition, it includes a GPS receiver, GPS antenna, cellular antenna, modem, operator keypad, microprocessor and controlling software.

The keypad allows the operator to transmit status information. It has four status keys and a key to initiate continuous operation. The status keys may be labeled to represent any desired function, such as, *at location, in service, out of service* and *emergency*. When these keys are activated, the location and status are sent to the *control center* for display and appropriate action. The operator keypad also provides visual feedback about the unit's operation, including: *ready, message received, continuous mode* and *error*.

Security and safety is improved by the VTU's capability to monitor and control switches in the vehicle such as theft alarms and panic buttons.

The cellular tracking unit uses the cellular airwaves effectively by making location transmission decisions based on operating conditions. For instance, considerable flexibility is provided by the VTU to transmit location data only when needed. In addition, transmission errors are routinely handled by the VTU automatically.



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If you require high quality communications service monitors to install or maintain systems for trunking, paging, land mobile or cellular and you provide field service as well as in-shop service, then contact IFR Systems at 1-800-835-2352 for a demonstration.

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of all the satellites "in view."

▶ *Mapping controller* — The mapping controller in the communications center has street names, addresses, city and state boundaries, bodies of water, railroads and other geographic features. Unique mapping information may be added to customize the maps.

A map can be configured to show the locations of all vehicles in a specific geographic area. Individual vehicles or groups of vehicles can be displayed on another monitor; thus, the dispatcher can isolate one vehicle on a monitor in an emergency. Displays may be large-screen, high-resolution monitors or wall-projection screens.

The mapping controller manages map display and manipulation and real-time vehicle location and status reports. It provides the operator with easy-to-use menu functions. A mouse or keyboard may be used to access the functions. Different geographic areas can be displayed on each monitor. Most systems use one to four monitors, although the controller can support as many as 16 monitors.

Vehicle mapping modes

- ***Follow*** **automatically moves the map as the vehicle position changes.**
- ***Zoom*** **follows a group of vehicles.**
- ***Area*** **keeps the map focused on a specific geographic *area*.**
- ***Point*** **keeps a particular point on the map in view, displaying fleet movement with respect to a given incident location.**

Each monitor can display all vehicles in any specific geographic area dynamically or track one or more vehicles with several types of map control. A variety of map functions control the specific geographic area and detail displayed on each monitor. The specific geographic area can be as large as the entire world or as small as a section of a city block.

High-definition-color street and road maps are available for the United States, most of Canada and many other countries. Digitized maps can be created for areas where only paper maps are currently available.

The size of the displayed geographic area on the monitor can be set by two different options, *zoom* and *magnify*. Zoom allows the operator to select the width of the area displayed in miles or kilometers. Zoom moves the view either closer or farther away using the same latitude and longitude as the map center. Magnify allows the operator to move to a smaller specific area within the displayed map. The operator uses a mouse-controlled cursor to select the area to be enlarged.

Several functions display different geographic areas. The view may be moved *north, south, east* or *west* in full-screen or half-screen increments. This function allows the operator to view a section adjacent to the displayed geographic area. The view also may be moved by selecting a new *center* for the map. This allows the operator to quickly see the vehicles around the particular point selected.

The view may be changed to a specific *point* as the center. Entering an address both centers the map and places a reference symbol on the map. The symbol represents the incident status or type of call. The operator has a visual reference of the incident location and can identify the closest vehicles.

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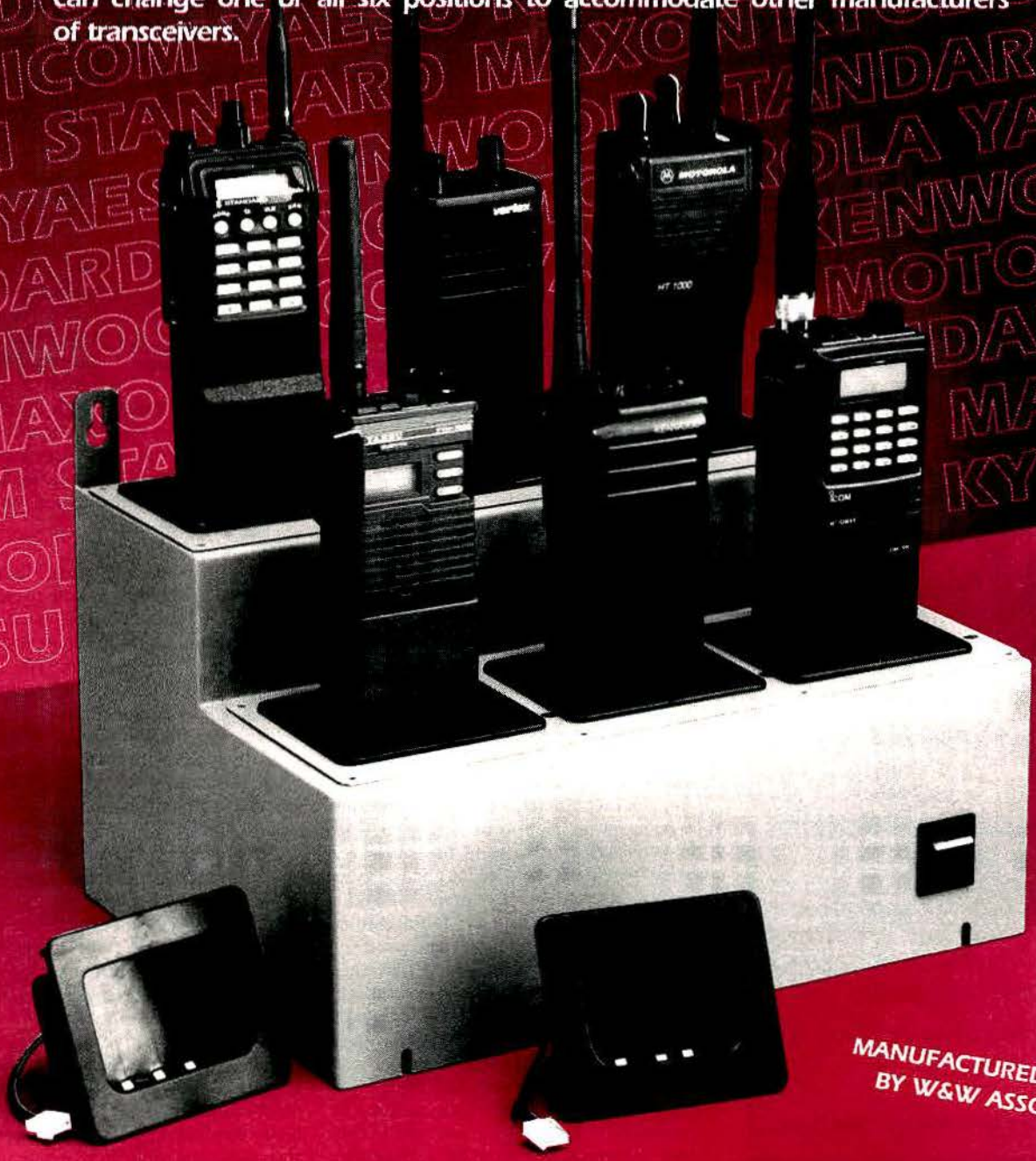

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Levels of detail displayed on the maps are easily controlled. The operator can set the magnification limits at which streets, highways, interstates and their names or numbers are displayed. This function allows the operator to see more information and detail at close range and to remove detail at larger distances to control screen clutter. The operator can request information about a specific street. The *address range* of each block can be displayed. The street's *name* can be requested if the detail level setting otherwise prevents the name from being displayed.

Any monitor can be set in either *area mode* or *vehicle mode*. Area mode allows the operator to view a specific geographic area, such as a county. Any vehicle in the selected geographic area is displayed on the monitor until it leaves the area. The vehicle mode allows one or more specific vehicles to be tracked on a monitor.

The mapping controller can keep several files on tracked vehicles to record each vehicle's status and location for future reports and review.

There are four vehicle modes. The first vehicle mode is to *follow* one or more vehicles at a constant zoom range. The system automatically moves the map as the vehicle position changes. The second vehicle-mode option is *zoom*, which follows a group of vehicles. If a vehicle goes off the displayed map, the system automatically "zooms out" to keep the vehicles on the displayed map. The third vehicle-mode option keeps the map focused on a specific geographic *area*. Vehicles are displayed as they move into the area. This mode allows a portion of the fleet to be assigned to a specific monitor for viewing. The fourth vehicle-mode option specifies a *point* on the map to be always in view. As vehicles move toward this point, the map "zooms in," and as they move away from this point, the map "zooms out." This function allows an incident location to be identified and fleet movement observed with respect to the given incident location.

The mapping controller can keep several files on tracked vehicles to record each vehicle's status and location for future reports and review. It keeps a chronological log of daily activities and vehicle updates that can be printed for auditing or review. The history files are used to "replay" a vehicle's activity for a given date and period of time.

A vehicle symbol's color can be set to correspond to vehicle status. An identification label can be displayed adjacent to the vehicle symbol. Label information can be taken from the vehicle database or from the vehicle location data. The label's information options include vehicle number, data base ID, unit ID, license number and note. These options allow the flexibility to display a short vehicle number or a longer identification, such as the driver's name.

The differential base station GPS receiver enhances the accuracy of the GPS data provided by the tracking unit. This correction typically boosts accuracies to within 10 meters, even with GPS *selective availability* (SA) turned on. (Selective availability reduces GPS receiver accuracy for non-military applications.)

The communications center can be integrated with user application software such as computer-aided dispatch systems and billing systems. Location information can be downloaded to other computer systems for other applications. Components may be expanded for growth.

Communications links

The AVL system must establish a communications link between the tracking unit and the control center. The choice of two-way communications link type depends on the reporting requirements. The tracking unit is designed to adapt to virtually any communications link.

Typically, two-way radio communications links used for fleet management include VHF and UHF radio, whether conventional (single-channel) or trunked (multichannel).

For applications requiring large coverage areas, the cellular telephone network is ideal. Other applications suitable for cellular include vehicle theft recovery, public safety and security operations. These emergency services are typically of short duration and require minimal network time.

Another alternative link between the tracking unit and control center is using communications satellites. This method is useful in monitoring trucks and other vehicles traveling long distances outside two-way radio and cellular coverage areas.

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Technically speaking

(continued from page 8)

$$(1)\quad Y_1 = \frac{1}{Z_1} = \frac{1}{50 + j25} = \left[\left(\frac{1}{50 + j25}\right)\left(\frac{50 - j25}{50 - j25}\right)\right] = \frac{50 - j25}{2{,}500 + 625} = \frac{50 - j25}{3{,}125} = (0.016 - j0.008)\text{S}$$

$$(2)\quad Y_2 = \frac{1}{Z_2} = \frac{1}{30 - j40} = \left[\left(\frac{1}{30 - j40}\right)\left(\frac{30 + j40}{30 + j40}\right)\right] = \frac{30 + j40}{900 + 1{,}600} = \frac{30 + j40}{2{,}500} = (0.012 + j0.016)\text{S}$$

$$(3)\quad \begin{array}{l} Y_1 = 0.016 - j0.008 \\ +Y_2 = 0.012 + j0.016 \\ \hline Y_T = 0.028 + j0.008 \end{array}$$

$$(4)\quad Z_T = \frac{1}{Y_T} = \frac{1}{0.028 + j0.008} = \left[\left(\frac{1}{0.028 + j0.008}\right)\left(\frac{0.028 - j0.008}{0.028 - j0.008}\right)\right] = \frac{0.028 - j0.008}{0.000784 + 0.000064} = \frac{0.028 - j0.008}{0.000848} = (33 - j9.4)\Omega$$

resultant impedance is the algebraic sum of the two. As shown in Figure 2 on page 8, the total resultant impedance, Z_T, is $(80 - j15)\Omega$. The two individual impedances can be replaced by a single impedance representing Z as shown in Figure 2B. Any number of complex impedances connected in series could be added algebraically to get the total resultant impedance.

The solution for total resultant impedance is not so simple when the complex impedances are connected in parallel. However, it does become simple if the impedance is converted to *admittance*. The individual admittances then can be added algebraically just as the impedances were in the series circuit. Before getting into that, let's talk about admittance for a moment.

$$(5)\quad jB = \frac{-X}{R^2 + X^2}$$

$$(6)\quad jX = \frac{-B}{G^2 + B^2}$$

$$(7)\quad G = \frac{R}{R^2 + X^2}$$

$$(8)\quad R = \frac{G}{G^2 + B^2}$$

Admittance

Admittance (Y), is the reciprocal of impedance, or $Y = 1/Z$. Admittance is measured in *siemens* (S). The old term was *mhos*, or *ohms* spelled backward. (I prefer the old term, but we will stick with current conventions.) There are several terms associated with admittance, just as with impedance. The reciprocal of reactance (X) is *susceptance* (B), that is, $B = 1/X$. Capacitive susceptance is B_C. Inductive susceptance is B_L. The reciprocal of resistance is conductance (G); that is, $G = 1/R$. Every part of a complex impedance has its reciprocal counterpart in the admittance form. Remember, all of the counterparts in the admittance form are measured in siemens. You will see the importance of all of this shortly.

In Figure 2, we had two complex impedances connected in series. The total resultant impedance was found by simply adding (algebraically) the two individual complex impedances. Now let's look at what happens when the same two complex impedances are connected in parallel. (See Figure 3 on page 8.)

Figure 3A shows the two impedances, Z_1 and Z_2, connected in parallel. The total impedance cannot be derived by simply adding the two complex impedances together as was done in Figure 2. When impedances are connected in parallel, it is easier to find the circuit's total impedance in terms of admittance.

First, the individual impedances must be converted to the equivalent admittance in complex form. (See the box above.) The admittance is equal to the reciprocal of

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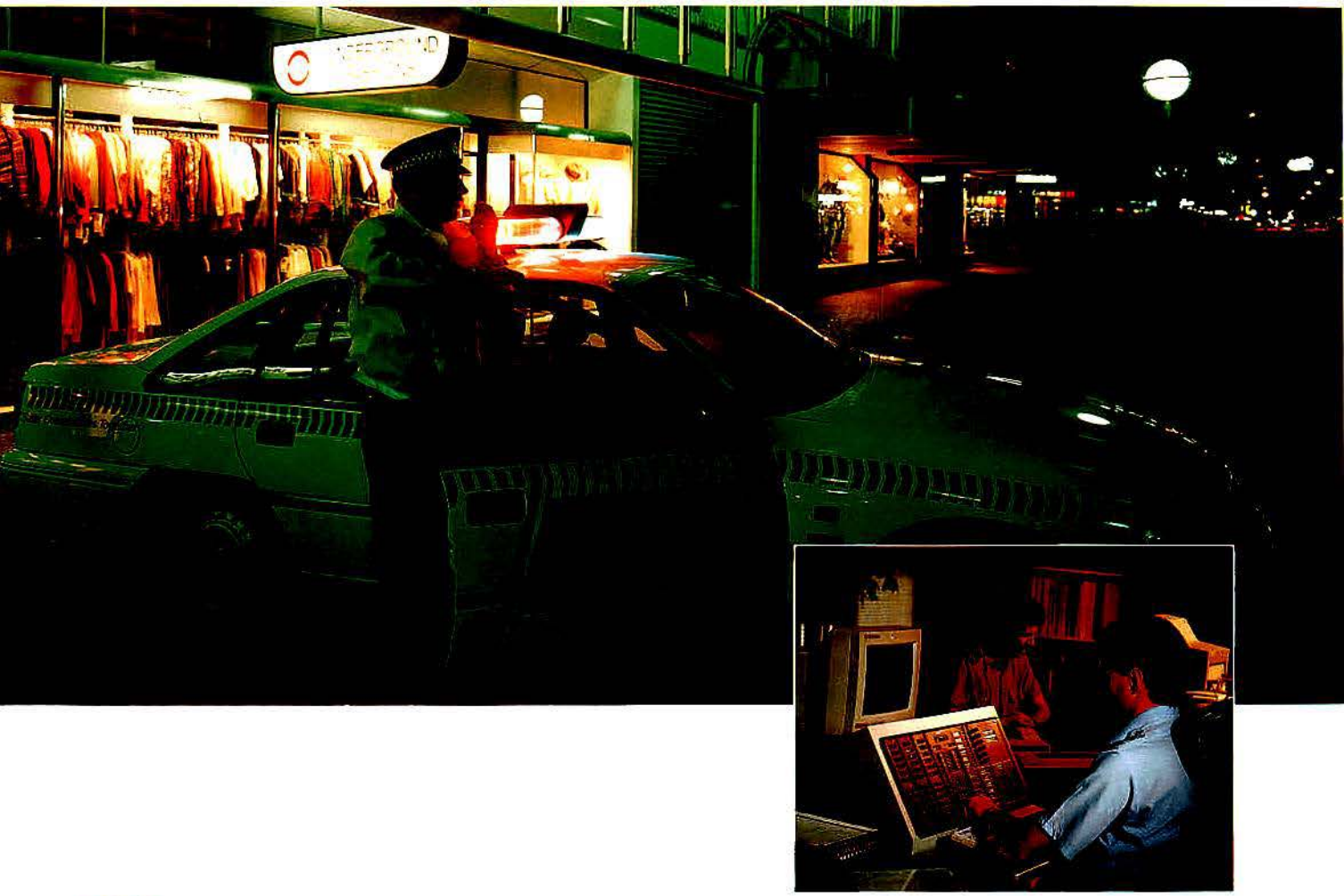

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impedance (1/Z) as shown in equations (1) and (2). The numerator and denominator are multiplied by the complex conjugate of the impedance, and the result is the admittance in siemens in complex form. Once the two admittance values, Y_1 and Y_2, are found, the total admittance, Y_T, is found by algebraically adding Y_1 and Y_2 as shown in equation (3) to obtain the total equivalent admittance, Y_T. The total equivalent admittance, Y_T, then can be converted to find the total equivalent impedance, Z_T, if desired. (See the math calculation in equation [4].)

Figures 3A to 3B follow this evolution through each step of the process. Figures 4A to 4F on page 56 show the component makeup of the impedances and admittances.

When the admittance is written in the complex form, the equivalent resistance and reactance is the reciprocal of the conductance (G) and susceptance (jB), respectively. For example, in Figure 4A, the reciprocal of the conductance (G) is 1/0.016S, or 62.5Ω. The inductance in Figure 4A is the reciprocal of 0.008S, or 125Ω.

The box at the bottom of page 52 provides some handy formulas for converting from complex impedance components to the equivalent complex admittance components, and vice versa. Equations (5) and (7) are used to convert the impedance components to equivalent admittance components. Equations (6) and (8) are used to convert the admittance components to the equivalent impedance components.

Polar coordinate form

As usual, there are other ways in which complex impedances or complex admittances can be represented. The *polar* coordinate form is often used to represent an impedance or admittance. This form provides the resultant impedance, $\sqrt{(R^2 + X^2)}$ and the phase angle, or the resultant admittance, $\sqrt{(G^2 + B^2)}$ and the phase angle. The box below provides some handy formulas for working with and converting between admittance and impedance in the polar form. In the polar form, the admittance is simply the reciprocal of the impedance (1/Z), and the phase angle is reversed by placing a minus sign in front of

POLAR COORDINATE FORM FOR IMPEDANCE AND ADMITTANCE

Where impedance is the polar form Z∠θ, these formulas apply:

(9) $jB = \frac{\sin(-\theta)}{Z}$ (10) $G = \frac{\cos(-\theta)}{Z}$

(11) $Y = \frac{1}{Z}\angle -\theta$ (12) $jX = Z \sin \theta$

(13) $R = Z \cos \theta$

Where admittance is the polar form Y∠θ these formulas apply:

(14) $jX = \frac{\sin(-\theta)}{Y}$ (15) $R = \frac{\cos(-\theta)}{Y}$

(16) $Z = \frac{1}{Y}\angle -\theta$ (17) $G = Y \cos \theta$

(18) $jB = Y \sin \theta$

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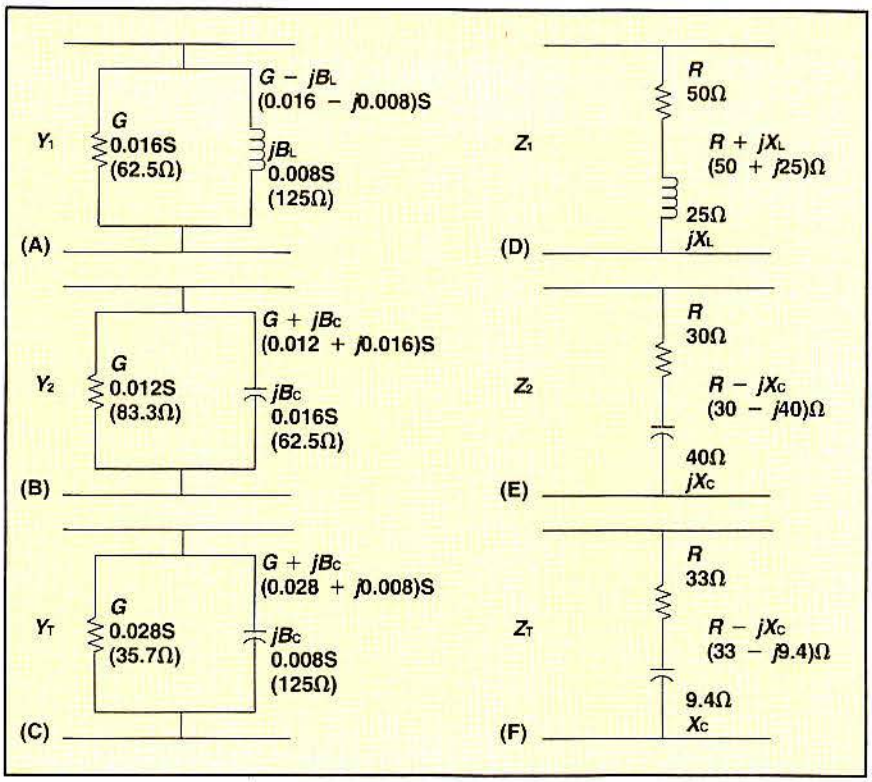

Figure 4. The component makeup of the impedances and admittances.

the angle (θ). Similarly, the impedance is the reciprocal of the admittance ($1/Y$) with the opposite phase angle.

Suppose that an impedance is written in the polar form as $45\angle 30°$. Formulas (9) through (13) on page 54 are applicable here. The reactance component (jX) can be found from formula (12), and it is $+22.5\Omega$. (The value sign is important). The resistance component (R) can be found from formula (13), and it is 39Ω. In the complex rectangular coordinate form, this would be written as $(30 + j22.5)\Omega$.

We also could calculate the admittance components, G and jB, from formulas (10) and (9), respectively. The conductance component, G, is 0.0192S, whereas the susceptance component, jB, is -0.0111S, or $Y = (0.0192 - j0.0111)$S.

All of this is just basic groundwork in preparing to work with the Smith chart. If you have a calculator that performs in the complex mode, these calculations are easily done. If not, use these formulas. Next month, we will get right into the use of the Smith chart in helping to solve practical problems.

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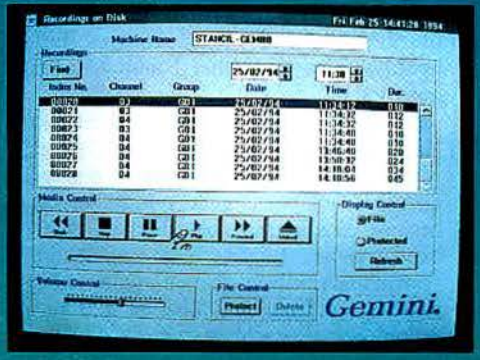

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Departing from 'old-school' automatic vehicle location

Opening vehicle location to the mass market requires new thinking and new technology. The emerging technology of radiolocating, intelligent, mobile data networks has the necessary architecture.

By James A. Pautler

Vehicle location technology can improve customer service, improve operating productivity in commercial fleets, reduce response times for public safety officers, or simply improve everyday driver convenience and security. Despite the attractive benefits, the drawbacks with commercially available technologies make most potential users hesitate to implement them. The biggest problem is the gap between what most potential users can afford and the price of available technology.

Existing AVL Technologies

Twenty years ago, the U.S. Coast Guard built the first successful location system, Loran-C, for coastal and inland water navigation. Since then, new terrestrial and satellite-based location technologies have been developed, ranging from dead-reckoning systems to the government-operated Global Positioning System (GPS).

Loran-C offers accuracy within ⅛ mile (¼ kilometer) in open areas and over water. Because the system operates at very low frequencies and has correspondingly long wavelengths, its signals do not penetrate urban "concrete canyons" effectively, which often leads to unacceptable position uncertainties. Loran-C provides no communication path for sending position information to a central management support center or for sending data messages.

Most vehicle location technologies use *navigational technologies* that fix the vehicle's position *relative to a coordinate system*. Although navigation is an important requirement for select applications (such as providing driving direction in an unfamiliar area), it does little to improve the efficiency or effectiveness of mobile operations with computer-aided automation. Most business or consumer applications do not need a system to tell the driver his own location. For automated or computer-aided vehicle management, the vehicle's position needs to be communicated to the dispatcher or a support center. Traditional automatic vehicle location (AVL)—determining vehicle location without driver involvement—does not completely solve any application problems; this technology rarely is used by itself.

Pautler is vice president of engineering at Pinpoint Communications, Dallas.

GPS has not been broadly implemented because GPS receivers have been relatively expensive and because it is a navigation system that resolves location in the vehicle only.

AVL usually is only part of a broader system for mobile resource management, routing, emergency aid or stolen vehicle recovery. Most of these applications require automated vehicle management (vs. simple monitoring), which implies a simultaneous need for two-way data communications and vehicle location. Therefore, a more practical AVL system should include remote radiolocation (making the vehicle location known at a remote point) and two-way data communication.

Early solutions that combine existing wireless data communications systems with navigation systems for locating, managing and supporting a roaming vehicle or fleet have resulted in high equipment cost because they forced together disparate pieces of equipment. Further, the cost of operation is driven higher by the need to transmit a vehicle's coordinates to the dispatcher or support center whenever required. As a result, only very few, high-value or sensitive applications (e.g., public safety and nuclear waste transportation) have been able to afford such technology.

Global Positioning System

Satellite-based systems can provide accurate position determinations (about 50m root-mean-square error for the commercial version of GPS) using signals received simultaneously from at least four orbiting satellites. Some organizations have AVL-oriented tracking systems that use this satellite-based navigation technology. These systems are not only expensive, but they also are technologically inadequate where improved location capability is needed most—downtown metropolitan areas. The low-power GPS signals can be lost when blocked by buildings, overpasses, billboards, trees and other common urban obstructions.

Another drawback is that standard GPS has an error factor as high as 200 feet, which can be unacceptable for some users. GPS has not been broadly implemented because GPS receivers have been relatively expensive and because it is a navigation system that resolves location in the vehicle only. To transmit this location data to a central operations or support facility that needs the vehicle location data, GPS must be linked via a data radio system. For a large transit agency with hundreds of vehicles, for example, several precious radio channels can be consumed for this task alone—if the necessary channels are available—and such radio systems can add considerably to the capital outlay required. For users without access to private radio

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channels, the cost of "renting" spectrum for AVL can be prohibitive.

These factors notwithstanding, GPS's use as an accurate navigational aid is rapidly replacing the function served by the older and less accurate Loran-C system.

Dead reckoning

"Dead reckoning" systems, such as those provided by ETAK, represent a navigation technology that uses vehicle-mounted sensors to estimate the distance and direction of travel, thereby determining location from the last known reference point. Reference points are determined by matching the vehicle's maneuvers to an onboard computer map of local roads. A dead reckoning system is expensive because it requires each vehicle to have a dedicated computer and an onboard geographic database. Again, the vehicle's position is not made known to the support organization because the system has no inherent communication capability. A data radio system must be added to transmit the location information.

Terrestrial radiolocation

Two other vehicle locating systems are the Teletrac and the Lo-jack stolen vehicle recovery systems. Teletrac uses a narrowband signaling channel, similar to a paging channel, to activate ranging signal transmission from a transponder in the vehicle being tracked. Ranging signal arrival times are measured at several receiver sites throughout a metropolitan area. At the network control center, the vehicle's location is determined by comparing the differences in arrival time of its ranging transmissions between pairs of receiver sites. The Teletrac system capacity is about 35 position fixes per second, and the system has a limited two-way message capacity.

The Lo-jack system also uses a paging channel to activate a beacon transmitter in protected vehicles. When a vehicle owner reports a missing vehicle, the paging channel is used to activate the beacon transmitter, which emits a user ID code on its homing carrier. Police vehicles equipped with Doppler direction-finding homing receivers then locate the vehicle by monitoring a combination of strength and direction readings of the signal received from the stolen vehicle. The limitations of this technology make it impossible to use it for communications.

Signpost systems detect the presence (and hence the position) of a vehicle when the vehicle responds to a scanning signal as it nears a signpost.

Signpost and tags

Another class of positioning and communication systems affect the mobile at discrete points in space, such as signpost systems and tag systems. They are based on a number of communication technologies, including infrared light (similar to those typically used by TV remote controls) and short-range radio.

Signpost systems detect the presence (and hence the position) of a vehicle when the vehicle responds to a scanning signal as it nears a signpost. Such systems can interrogate the vehicle for identification, status

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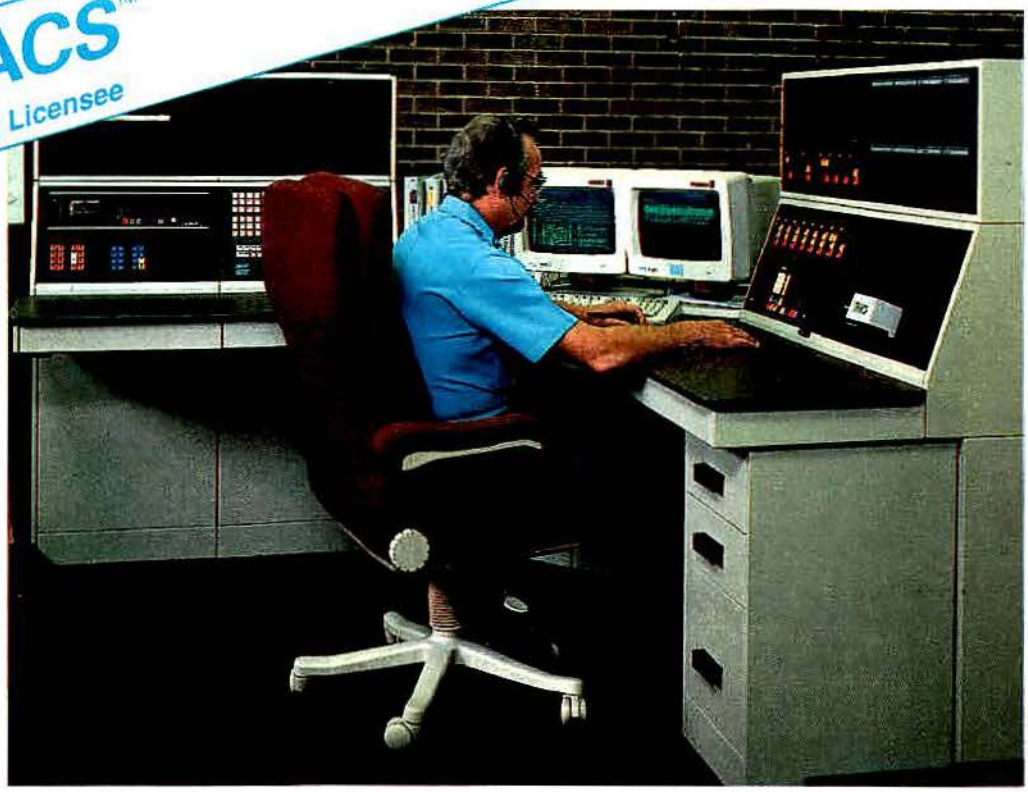

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and destination. They can download information such as road conditions, weather forecasts and routing information.

A special class of these systems called *modulated backscatter tags* is enjoying widespread success in automated toll collection systems, vehicle identification systems and vehicle tracking systems (such as the tracking of railcars across the country.)

The designs include both passive and active tags. The passive tag is powered by the illuminating energy from the nearby tag reader, which bathes the tag in radio energy as it passes. Circuitry in the tag modulates the tag's reflectivity with internal data, such as identification or status, which are then received and decoded by the reader. Active tags can be polled, their identification can be determined, and then data can be either downloaded or uploaded by the reader. Still, such systems only provide rudimentary location information because they only identify the position of the vehicle when it is close to a reader. No information about its location is known otherwise.

Precursors of wide-area, radiolocating data networks, such as the terrestrial radiolocation network of Teletrac, have been used primarily to satisfy niche markets, such as stolen vehicle recovery, emergency breakdown service and elementary fleet management functions. They provide a glimpse of the potential benefits of a modern, redefined AVL system.

Integrating location and communication

Wireless communications systems historically have been implemented separately to provide either mobile voice communications or automatic vehicle location. In some cases, data communications later are retrofitted to voice systems.

Unfortunately, voice-oriented communication systems are generally unsuited for efficient and economical communication of short data messages common to many mobile applications. Also, existing navigation systems are not cost-effective for automating mobile unit location determination.

Previously, few radio networks have been optimized for data communications and, further, simultaneous radio data communications and vehicle location have not been integrated into a single network technology. Now, radiolocating intelligent mobile data networks (IMDNs) are being built that use spectrum-efficient protocols and that minimize many of the ranging and data-rate limitations caused by multipath distortion.

AVL and mobile data communications need new technological approaches that can meet the needs of a broad range of

applications. Such a technology must provide communication and location solutions to large numbers of users at a low cost for equipment and use.

In the future, AVL systems will promote or enable the widespread implementation of automatic vehicle management because most automated vehicle management applications require both remote vehicle location and two-way mobile data capabilities.

Mobile data communications

Many radio data communications have relied on suitably modified analog data modems used on voice radio systems such as specialized mobile radio (SMR) or cellular radiotelephone (CRT). Dedicated packet data radio networks, such as ARDIS

In the future, AVL systems will promote or enable the widespread implementation of automatic vehicle management . . .

and RAM Mobile Data, overcome some of the weaknesses of voice-oriented radio architectures. Unfortunately, they all are based on voice-radio channels with capacities that limit data transmission rates to 4,800bps to 19,200bps, and more typically to less than 9,600bps of effective user data throughput, depending on the radio environment and equipment sophistication.

These low data rates and inefficient voice channel-oriented protocols limit the maximum number of subscribers to much less than tens of thousands per channel. The relatively high equipment and operating costs of these technologies can be justified for only a few mobile applications.

Some satellite-based mobile data communications, often referred to as mobile satellite service (MSS), have been established. Whereas satellite-based systems can provide nationwide coverage, they are extremely expensive, and none currently provide location information accurate enough for metropolitan applications. Further, such systems support only very low data rates, and only a few specific customers can afford the ubiquitous coverage. Qualcomm, for example, has primarily offered the service to large, long-distance trucking companies that want to stay in contact with their cross-country fleets.

Developers of the new-generation IMDN

used an integrated approach to design a network optimized for high efficiency at the small transaction or message sizes typical of many mobile applications (in the range of tens to hundreds of characters per message). This IMDN achieves high performance and capacity by communicating only data via a broadband channel architecture with a uniquely integrated, high-efficiency, packet protocol. The network uses direct-sequence, spread-spectrum modulation to give message data signal the characteristics necessary for radiolocation (similar to those used in modern radar). These characteristics, combined with an efficient hybrid-access protocol, allow the network to deliver locally more than 1,500 20-byte packets, or to provide as many as 3,000 position fixes, per second. This level of performance is accomplished by using data message delivery as part of the radiolocation process. Tight synchronization across the network helps to achieve high data rates and excellent radiolocation accuracy.

Location monitoring IMDN applications

This modern, radiolocating mobile data network does more than combine remote vehicle location and mobile packet data communications. The network's use of industry standard application interface protocols provides a simple interface for end-users and greatly reduces the implementation efforts of application developers. The radio modem interface uses an RS-232 connection and a landline modem-like AT command interface that support personal computers with common communications software. End-user applications interface to the network control center using common data protocols like TCP/IP.

Vehicle location information also helps to increase driver and passenger security.

The system shares the radio spectrum and the sophisticated common network infrastructure among a large number of subscribers to minimize the cost to any one subscriber. The network offers a harmoniously integrated set of access protocols for both two-way data communications and automatic radiolocation.

Some of the applications enabled by the radiolocating IMDN include:

- *Fleet management*—The fleet manager needs to know the location of each vehicle to select the best one to dispatch, to send information (e.g., dispatch instructions and information, and directions) and to receive information (e.g., vehicle status, onboard inventory status and transaction information).
- *Emergency roadside services*—A roadside service provider needs to know the nature of an emergency (e.g., out of gas, flat tire, breakdown and dangerous situation) as well as the location of the vehicle having trouble. The service provider also needs to tell the subscriber who is responding and when help will arrive.

Vehicle location information also helps to increase driver and passenger security. Activating an emergency button on the in-vehicle terminal can alert the police, and/or a mass transit or cab dispatch center of a robbery, an assault, a medical emergency

or vandalism while pinpointing the exact location.

□ *Vehicle security monitoring*—The security monitoring firm wants to know the location of the vehicle and the nature of the alarm (e.g., glass breakage, ignition without key, fire and unauthorized movement.) In addition, the monitoring firm needs to be able to trigger actuators in the vehicle (e.g., turn horn and lights on, turn ignition or fuel system off.)

□ *'Smart car' systems*—These systems track the location of a large number of vehicles to help to spot traffic congestion as it develops. Smart-car, smart-highway management systems could get information from the vehicle about its intended destination and then send information to the vehicle to route it around traffic problems.

Realistic applications

Real applications need a system that can provide adequate performance and flexibility. For example, response time may be poor when a cab or police is not dispatched correctly because the last available position fix is too old or if it takes too long to get a new fix. Position fix accuracy also is critical because locating a police officer needing assistance or a disabled vehicle in an urban area to within a one-block radius is not good enough.

The redefined AVL system of the future must deliver capabilities such as fast response time, high-speed message delivery and position fixing throughput, low operating cost (to the user) and easy application interfacing to be able to serve the majority of automated vehicle management applications. The technology that enables such a service has been developed, and the advantages of these modern spectrum-efficient networks are their inherent low cost, large subscriber capacities, high-speed data communications and fast, accurate vehicle location.

Technology driving the union

Many developments are contributing to new understandings, improved capabilities and lower costs in location monitoring and wireless data communications. These factors include a growing sophistication and high manufacturing volumes combined with microprocessor and signal processing developments; sophisticated signal processing techniques developed for satellite and radar signal analysis; and the volume production of mass communication markets such as paging and cellular radiotelephone.

By combining and/or leveraging many of these new technologies, it is possible to create a modern intelligent mobile data network with mass-market appeal. Such an

IMDN can produce order-of-magnitude improvements in performance and cost reduction over prior approaches that combine separate navigation and communications technologies.

By operating in the currently available AVL spectrum, a well-designed IMDN overcomes much of the distortion that multipath scattering causes for radiolocation. Sophisticated wideband signal processing can significantly increase the reliability of IMDN packet data transmission by combining the message signal energy in each of the multipath echoes, a process that is generally not available in conventional narrowband, carrier-wave modulating radio communications approaches.

Some minimum requirements

A few companies can now demonstrate IMDN technologies that provide:

(1) fast, remote vehicle location with as many as 1,500 position fixes per second in a local area or 7,500 position fixes per second across a large metropolitan system.

(2) high-speed, two-way packet data communications as fast as 38,400 bytes per second.

(3) integrated, transponder-modem designs that cost much less than $500 retail in early production.

The emergence of such IMDNs makes it possible to inexpensively support the sophisticated communications needs of mobile management applications for millions of subscribers in each metropolitan area.

Pinpoint Communications' IMDN architectural approach builds upon the premise of combined remote radiolocation and mobile packet data communications and effectively reduces the cost of mobile equipment and network infrastructure to a level permitting mass-market acceptance. This approach allows the network to achieve a high subscriber capacity.

A well-designed IMDN makes efficient use of a wide spectrum allocation because it performs data communications and AVL simultaneously in the same band, at the same time, with the same signal.

There are many possible communications systems architectures that would be acceptable for implementing automated vehicle management. Each architecture would be likely to use its own set of protocols for telecommunications, radio operation and terminal operation. Because many applications have similar needs, it is likely the disparate systems would have many "intelligent" features in common. The industry will benefit if providers of such architectures develop compatible industry standards for access to those common features. This would simplify the movement of applications from one communications offering to another.

Spectrum — an AVL priority

A scarce and valuable public resource, spectrum needs to be allocated and used in the most efficient manner. Used alone (without data communications), AVL presents a serious allocation question. High-speed terrestrial radiolocation technology

requires a wide bandwidth for quick and accurate position determination. Because AVL without data communications does not completely solve the needs of most potential users, it is difficult to justify dedicating large portions of spectrum to a narrowly limited function (such as independent radiolocation) while needing still more spectrum to satisfy the data communications functions.

A more efficient use of spectrum would support both high-volume data communications and fast, remote radiolocation. A well-designed IMDN makes efficient use of a wide spectrum allocation because it performs data communications and AVL simultaneously in the same band, at the same time, with the same signal.

Severe multipath fading, signal shadowing and scattering distortion in the typical metropolitan area challenge mobile communications engineers who design reliable communications links. Interaction among metropolitan mobile communications characteristics and the available bandwidth with the IMDN communications architecture dramatically improves the rate at which position fixes can be made and the volume of data that can be communicated.

Future of radiolocating IMDNs

Combining navigational AVL with a separate, conventional data communications system is too expensive to be within the reach of most potential users, so AVL must be harmoniously integrated with mobile data communications to provide low-cost, high-performance service. The intelligent mobile data radiolocation networks have the ncessary architecture.

Moreover, as airwaves grow more congested and spectrum becomes more precious, AVL-only and voice bandwidth-based mobile data communications will have difficulty operating as separate, standalone services. The future of this technology lies in its ability to adapt to the changing needs of mobile communications users who demand efficiency and cost-effectiveness through integrated solutions.

For more information about the companies mentioned in this article, circle the numbers on the Fast Fact Card on page 105 as indicated below.

Etak
Circle (310) on Fast Fact Card

Lo-jack
Circle (311) on Fast Fact Card

PacTel Teletrac
Circle (312) on Fast Fact Card

Pinpoint Communications
Circle (313) on Fast Fact Card

Qualcomm
Circle (314) on Fast Fact Card

Big Brother and the Holding Company

By Robert H. Schwaninger Jr.

While the FCC is praising the efficiencies that digital technology will bring to the marketplace, another part of the federal government is complaining about this technological breakthrough. None other than the law enforcement community has noted that its time-tested surveillance methods might not make the switch from analog to digital.

As you know, anyone with a few bucks worth of gear from the hobby shop can eavesdrop on analog traffic. But with digital technology, including the telephone companies' increasing use of Integrated Services Digital Networks (ISDNs), the job of identifying the content of the bad guys' telephone and cellular conversations becomes far more difficult.

The White House has been asked to help the cops find easier ways to listen in, and the White House has cooperated by sending to Congress the Digital Telephony and Communications Privacy Act of 1994. This legislation would require carriers to provide law enforcement agencies with the following:

- setup information regarding a caller's data communications for interception of the call by officials or the carrier.

- an employee to handle requests for interception of conversation by law enforcement personnel.
- the ability to transmit the content of conversations to locations chosen by law enforcement officials.
- the identification of hardware and software required to provide interception capability.

The intent of the proposed law is to assist the FBI in intercepting conversations over cellular, electronic mail, call forwarding and other messaging methods that presently cause interception headaches for their agents. In sum, the Act is intended to force carriers to cooperate by assisting in wiretapping (or radio tapping).

Although no right-thinking individual wants criminals to be able to operate over the nation's airwaves and wireline network

Schwaninger, *MRT's* regulatory consultant, is a partner in the law firm of Brown and Schwaninger, Washington, DC. He is a member of the Radio Club of America.

with impunity, there is some question as to whether the proposed law crosses the line of permissible cooperation. One must question whether the right to privacy is properly protected, whether the FBI should be forcing cooperation from carriers, and whether there is any justification for such intrusion into the operation of common carrier facilities.

Perhaps the most chilling aspects of the law are the unspoken elements. How much interception is presently taking place in an analog environment? Most people recognize that, given proper judicial oversight, a warrant authorizing a wiretap can be acquired. But does the new law create an environment for abuse? Does it suggest that interception is far more common than we would like to consider? Sometimes the unrevealed nature of a request is far more threatening than what appears on the surface.

As we move closer to the new Information Superhighway system, perhaps now is the proper time to decide when and where we will construct speed traps.

MCI comes to Nextel

MCI, the nation's second-largest long-distance carrier, has decided to enter the wireless communications business by acquiring 17% of Nextel Communications for $1.3 billion. MCI is the latest to join the Nextel cadre of equity owners, which is quickly becoming a *Who's Who* of the telecommunications marketplace.

MCI joins previous participants Matsushita, Nippon Telephone and Telegraph, Motorola and Comcast in buying positions in Nextel to bring new wireless data transmission services to the public that are intended to link phone, fax, computer, pagers, television and, perhaps, garage door openers into a single integrated service.

Nextel explains MCI's participation as providing the cash to bring the service to the marketplace rapidly by building the capacity to serve 95% of the United States population by 1996. This heady goal is laudable in the face of reality.

A review of the FCC's database shows that, even with all of the channels Motorola chipped in to acquire its participation in Nextel, the company is still far short of its stated goal. Given the fact that the FCC's latest speed-of-service report showed that the processing time for an SMR application is, on average, 266 days, one has to wonder whether Nextel will be able to make it by 1996.

In addition, Nextel's frequency reuse plan and system designs, which are publicly available, suggest that Nextel will require at least 75 channels in a major

market area and that multiple, additional transmission sites will be required. Assuming that Nextel can acquire the necessary spectrum in the top 100 markets from existing licensees, Nextel will still need to build as many as 7,500 channels at hundreds of sites across the United States.

I admire what Nextel already has accomplished in a relatively short time. The organization and the financial capacity that have been exhibited are extremely impressive by any measure. Combining the forces of Matsushita (Panasonic) and Motorola and MCI is a coup. But full construction by 1996?

Every operator in this industry has gone through the problem of finding sites, acquiring leases, negotiating maintenance contracts and finding personnel for construction. Nextel's goal seems to ignore the realities of constructing a vast network in varying weather and local economic conditions. Can the company do it?

There were naysayers when MCI took on AT&T. There were people who scoffed at McCaw when it went on its cellular binge. There were spectators who said that Southwestern Bell was paying too much for Metromedia. The industry is filled with people who have analyzed deal after deal and have mistakenly found them wanting. Every time a company makes a big play, people will have doubts.

So if you question whether Nextel can achieve its goals, you are part of a long tradition in the industry. If you believe that Nextel will succeed, you are among those who have been convinced by the evidence of recent successes of other aggressive companies that have sought to change the way the industry thinks about the delivery of telecommunications services.

No matter whether you are a doubter or a rooter, everyone seems to think that Nextel will reshape the SMR industry, the wireless industry and the mobile data community. What shape these industries will take is still open to speculation, but one thing is sure. If the White House gets involved, the digital technology that delivers the services will have a few folks listening in at all times.

Midland alters distribution, adds antennas, hand-helds

At its mid-March ProCom '94 dealer conference in Cabo San Lucas, South Baja California, Mexico, Midland International announced the reorganization of its distribution network. In addition, the Kansas City, MO-based company demonstrated to its dealers a new line of mobile antennas and new hand-held transceivers. Also announced was LTR-compatible UHF equipment. Future technology that the company has under development, a new single-frequency duplex transceiver, was demonstrated. Furthermore, plans to produce digital radio equipment were announced. It was also revealed that Simmonds Communications, Willowdale, Ontario, Canada, is involved in a 220MHz radio communications carrier network joint venture to serve motor carriers along interstate highways and in cities. Midland is owned by SCL, a U.S. subsidiary of Simmonds Communications.

Scott Henderson, president of Midland Communications, Midland's sales and service business unit for the United States and South America, announced that the

company will replace about 600 of its U.S. land mobile radio dealers with 150 "franchise dealers." Franchise dealers will be given protected geographic sales areas, the right to form their own dealer networks within their areas, and the right to sell certain additional products from the company's consumer products line. A franchise dealer council was formed to offer the manufacturer advice. Membership on the council will rotate periodically among the various franchise dealers.

Midland LMR has introduced mobile antennas for frequencies from VHF lowband to 800/900MHz. The antennas are made with nonferrous metals and alloys to eliminate rust and with gold-plated contacts to improve conductivity. The antennas come in a variety of mounting styles, including window mounts for most frequency bands. The antennas are discounted to attract dealer sales. Midland has not previously offered land mobile radio antennas.

Midland also has announced LTR-compatible trunking equipment for UHF. The equipment includes hand-held transceivers, mobile transceivers and base stations for the 406MHz–430MHz and 450MHz–470MHz bands.

Later this year, the company will offer miniature hand-held transceivers for the VHF, UHF and 800MHz bands. The miniature hand-held transceivers will complement the company's line of mobile transceivers. It has been several years since the company previously updated its hand-held transceivers.

Harry Dunstan, president of SCL, said that in about a year, Midland will bring to market a mobile transceiver that uses analog audio time compression and expansion and that toggles between transmit and receive five times per second to achieve full-duplex radio communication on a single frequency. The unit that the company demonstrated at its March meeting operates on either 12.5kHz or 25kHz channels. Single-frequency duplex technology eliminates the need for a frequency pair, thereby doubling the communications capacity. For example, a 25kHz frequency pair can carry two separate conversations, one on each frequency, when used with the new radio. Where splitting the 25kHz channel into two 12.5kHz channels is allowed, the capacity can be increased by a factor of four.

Another technology under development is a digital transceiver that will allow Midland to compete for additional private communications network equipment sales.

John Simmonds, chairman of Simmonds Communications, said that, as its involvement in the systems integration business grows, Midland and some of its dealers will help with the construction of a 220MHz public communications network that will include base stations and switching equipment with RF coverage along interstate highways and in cities. The system will be built under the authority of licenses controlled by Intek Diversified, a joint venture owned in part by Simmonds Communications, Roamer One and other investors. Roamer One is a company that was formed to apply for 220MHz licenses that were awarded by lottery. Applications were filed for station sites consistent with plans for the network design. Midland will assist in the construction of the network, and its dealers have an opportunity to participate in its installation and service.

New products

Reader's choice

Of all the new products and services in the September 1993 issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them. Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

Compact GPS unit stores 99 destinations, five preprogrammed routes

The KX-G5500 Global Positioning System (GPS) receiver from **Panasonic** offers full navigational functions and an internal memory that stores as many as 99 waypoints (destinations) plus nine preprogrammed routes. The five-channel digital parallel receiver can display latitude and longitude in two dimensions or add altitude for three-dimensional navigation. Positions can be displayed either in degrees, minutes or hundredths or in degrees, minutes and seconds. The receiver measures 5½" × 2⅝" × 1½" and weighs 11.6 ounces.

Circle (500) on Fast Fact Card

Software simplifies calculation of base station antenna patterns

RF Tools software program from **Antenna Specialists** helps communication system designers and operators with base antennas calculate and tailor antennas to their own system requirements. Three disks are included: "Dxplot" permits precise calculation of beamtilt coverage; "Patplot" displays and plots digitized base antenna patterns; and "Antplot" develops patterns for side-mounted base antennas. The programs are available on 5¼" IBM-compatible disks, or they can be downloaded through Antenna Specialist's remote bulletin board service.

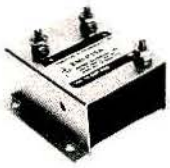
Circle (501) on Fast Fact Card

Pocket-size radio offers 2W VHF output, privacy option, charger

The model T-20 hand-held radio from **Tekk** is a pocket-size VHF radio molded in rugged Lexan plastic. The one-channel radio is FCC type-accepted and has 2W of output power. Features include a slide-in privacy option, a speaker/microphone jack and an optional one-hour charger. Cases are available in black or high-visibility yellow.

Circle (350) on Fast Fact Card

Noise filter protects communications from power, accessory interference



Marine Technology introduces the EMI-P15A noise filter, which protects communications equipment from power line interference and isolates noise-producing accessories. The 12V, 20A filter is designed to eliminate alternator whine and interference in commercial AM/FM/SSB/VHF radiotelephone equipment. It also will prevent interference developed by noisy accessories such as 12Vdc to 120Vac inverters, large 12V motors in fans, pumps and blowers, or stobe and signal lights.

Circle (351) on Fast Fact Card

Scrambler provides cellular phone privacy, maintains voice quality

The Crypto Voice Plus (CVP) voice privacy module from **Transcrypt International** secures conversations on the Motorola MicroTAC phone when used with a corresponding scrambling module in another cellular or wireline phone. The module is embedded internally and does not change the size or appearance of the phone. The CVP module technology combines digital and analog voice privacy technology to provide security without sacrificing recovered voice quality.

Circle (352) on Fast Fact Card

Extra repeater capacity allows custom channel configuration by carrier

The Extend-A-Cell EAC-2000 repeater from **Allen Telecom Group (ATG)** doubles the channel capacity of ATG's previous repeater technologies by providing for modular growth of as many as 10 channels per unit. This allows custom configuration to a carrier's specific requirements. Providing twice the channel capacity of a single repeater, the EAC-2000 unit allows wireless telecommunications operators to expand and improve coverage areas while incrementally reducing costs. Factoring in the typical price of ATG's five-channel repeater, the EAC-2000 provides a 30 percent reduction in cost-per-channel operation. An upgrade kit available later this year, consisting of a new logic interface, a new power amplifier and new software, will allow TDMA digital operation.

Circle (353) on Fast Fact Card

New products

Mobile radio's options, durability address business and pubic safety needs

The Viking HT series LTR mobile radio from **E.F. Johnson** operates in both LTR and conventional formats at either 800MHz or 900MHz. The HT version meets all MIL STD 810 standards for shock, vibration, driving rain and blowing dust. The radio features six programmable option buttons, a 10-character alpha display, 5W internal speaker and knob controls. Other functions include emergency call, voice encryption, prestored interconnect calls, group scan and dual priority scan on conventional channels.

Circle (354) on Fast Fact Card

Hand-held reflectometer enables fast and easy cable fault location

Riser-Bond Instruments introduces the Line Judge model 1000 hand-held digital time domain reflectometer (TDR). The model 1000 can be used for fast and easy cable fault location or as a digital tape measure for measuring cable lengths on the reel or already installed. The user enters the velocity of propagation of the cable into the model 1000 and turns it on. The distance to a major cable fault is instantly displayed. All distance measurements are within ±1% accuracy. The model 1000 can be used to test all types of coaxial, twisted pair or metallic paired cables. The LCD shows distance to fault in feet or meters and indicates whether the fault is an open or short.

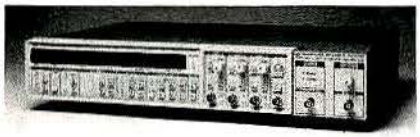
Circle (355) on Fast Fact Card

High-speed radio modem's features allow point-to-point or network use

The DDR-96 high-speed, multichannel radio modem from **Pacific Crest** is designed for applications such as remote monitoring and control, DGPS and mobile dispatch. Transparent, packet-switched and repeater modes allow the DDR-96 to be used in simple point-to-point radio data links or in sophisticated radio data networks where multiple units share a single frequency. The interface is user-configurable for 300 to 9,600 baud with a transmission rate of 9,600bps or 4,800bps. The modem is available in two frequency ranges, 403MHz–430MHz or 450MHz–470MHz. The unit features a 2W synthesized radio transceiver, forward error correction, digital squelch control and sleep mode.

Circle (356) on Fast Fact Card

Frequency counter delivers 12-digit accuracy with rubidium timebase



The SR625 frequency counter from **Stanford Research Systems** traces the frequency calibrations of base stations, transmitters and other communications systems. The high-resolution unit uses a rubidium timebase to measure frequency drift and stability. The counter directly measures signals as high as 2.2GHz with 12 digits of resolution in a one second measurement interval. The rubidium timebase has an accuracy of 5×10^{-11} and a monthly drift of 5×10^{-11}. A 10MHz rubidium output drives other test equipment such as spectrum analyzers or synthesizers.

Circle (357) on Fast Fact Card

Small flat panel antenna design allows versatility in placement

About the size and weight of a telephone book, the FP-5509-1 flat panel antenna from **Radiation Systems' Mark Antenna Div.** is suitable for cellular, SCADA, SMR and GSM services. The 2"D × 9"W antenna is available in a variety of frequencies in the 806MHz–960MHz range. At four pounds, it can be mounted almost anywhere, including on a building or a pipe. Featuring a gain of 5.7dB, the low-profile antenna is constructed of aluminum and housed in paintable, white ABS plastic.

Circle (358) on Fast Fact Card

SC-style connector installs quickly for high-density fiber connections

Automatic Tool & Connector introduces a simplified, four-piece, SC-style connector for fiber-optic systems requiring high-density connections. Both the single-mode and multimode connectors offer push-pull coupling for fast installation. Features include a precise-polish zirconia ferrule for improved return loss (≤−35dB PC Polish and ≤−45dB Super PC). The connector has a low insertion loss of 0.1dB multimode and 0.2dB single mode.

Circle (359) on Fast Fact Card

Site alarm permits output monitors to be combined with site security

The WatchDog site alarm from **IDA**, developed by Pacific Circuit Design, is RF-controlled with DTMF signaling. It responds in selective formats: DTMF, Morse, two-tone paging or on-air tones. The site alarm's 24 input combinations can be connected with as many as 20 individual transmitter output monitors, as well as with VSWR and tower light monitors, intrusion alarms and site identification equipment. The alarm has eight latched outputs for remote control of heaters and air conditioners. The DTMF signaling works with P.C. Dispatch Console software, allowing sites and individual alarms to be identified, selected, controlled, logged and printed.

Circle (360) on Fast Fact Card

Radio modem ties mobile data unit to database, computer-aided dispatch

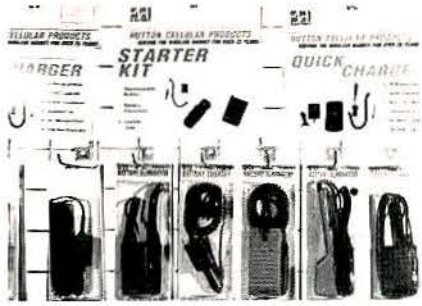
Data911 announces its Mobile Data System (MDS) for public safety vehicles. The system allows officers to submit their own database inquiries; receive, send and store messages; change unit status; modify computer-aided dispatch incident information; and enter case reports from the patrol car. The MDS features a full-size LCD touchscreen, an IBM PC-compatible processor for multitasking, a high-speed radio modem and a removable memory card. The MDS software also checks officers' entries for errors and gives context-sensitive help.

Circle (361) on Fast Fact Card

Cellular accessories line premieres with starter kit and quick charger

Hutton Communications has introduced Hutton Cellular Products, a line of batteries, chargers, eliminators and starter kits for cellular phones. The starter kit includes a rechargeable battery, a battery eliminator and a leather case. The quick charger/conditioner has a 29 minute in-vehicle recharge time and also conditions batteries out of the vehicle.

Circle (362) on Fast Fact Card



RF signal strength meter includes optional setup for GPS and PCMCIA

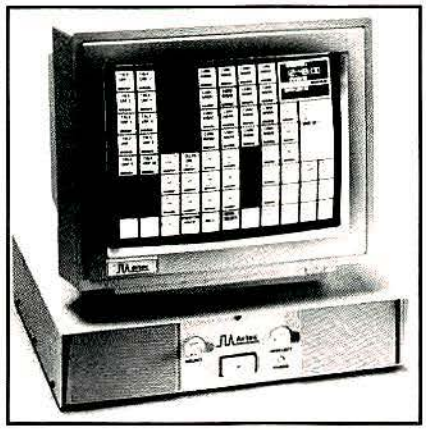
The Champ RF signal strength meter from **Berkeley Varitronics Systems** works for both analog and digital modulation systems. Unit sensitivity is −120dBm to −30dBm. Determination of optimum frequency from 900MHz to 932MHz is made with internal, autocalibrating RSSI detector circuits. Readouts are shown on a 240 × 64 pixel supertwist EL backlit LCD. Internal NiCd batteries provide an eight-hour operating life, or the unit can be run on included adapters for auto lighters or external dc. Options available for the hand-held, real-time meter include internal six-channel Global Positioning System (GPS) navigation and PCMCIA memory cards.

Circle (363) on Fast Fact Card

Color touchscreen console system employs digital signal processing

DSPatch is a color touchscreen console system from **Avtec** that employs digital signal processors (DSPs) at every line and console. The distributed architecture provides instant responses even in large systems. The central rack equipment may be configured to support from 32 to 1,024 external lines or operator workstations. External line applications include conventional radio, trunked radio, telephone circuits and intercom circuits. Operator workstations may be connected locally or remotely connected using a modem.

Circle (364) on Fast Fact Card



Fire-retardant cables provide option for tunnel and building applications

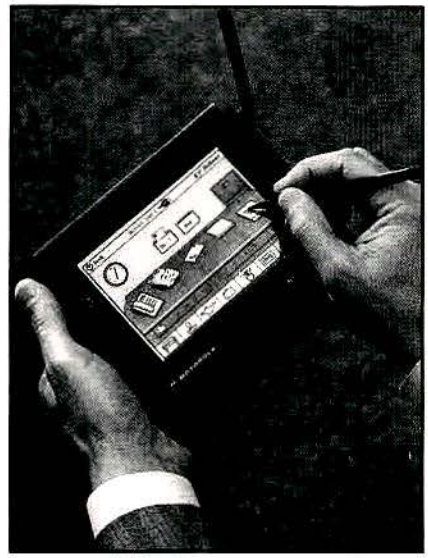
Three sizes have been added to **Andrew's** line of radiating coaxial cables. The new cables are the 7/8" model RXL5-1RNT1, the 1¼" model RXL6-1RNT1 and the 1⅝" model RXL7-1RNT1. The RNT1 series cables use non-halogenated, low-smoke, low-toxicity, fire-retardant jackets. They incorporate barrier tapes of an inert material that does not burn or melt, and they are compliant with vertical flame tray tests. The cables are suitable for installations where riser or plenum ratings are not required.

Circle (365) on Fast Fact Card

New products

Wireless communicator provides personal information, data management

The **Motorola** Envoy personal, handheld wireless communicator provides two-way wireless, wireline and infrared communications. The unit, to be released this summer, uses Motorola's I/68349, 32-bit 16MHz microprocesser. The Envoy communicates with electronic mail systems, Windows-based computers, Macintosh computers, fax machines and other Envoy communicators. A built-in, two-way wireless packet data modem provides access to AT&T PersonaLink Services and RadioMail over the Ardis network. Integrated hardware includes two PCMCIA Type II slots, a 480 × 320 resolution LCD touchscreen operated by stylus or finger touch, a smart peripheral port, rechargeable NiCd battery, owner identification security circuitry, 1MB of RAM and 4MB of ROM. Information can be input with an on-screen keyboard or with a stylus. In addition to numerous built-in personal management tools, 15 third-party software applications and services will be available. The 1.7-pound communicator measures 7.5"W × 5.7"H × 1.2"D.



Circle (366) on Fast Fact Card

Radiating cable, transmission line are first releases in coaxial expansion

The AirCell product line from **Trilogy Communications** introduces AirCell Radiating Cable, available in two impedances. The cable is designed for communications in highly developed or underground locations such as tunnels or subways. The AirCell line also introduces MC² 50Ω transmission line. All Trilogy cable products are available with an optional, zero-halogen, fire-retardant jacket.

Circle (367) on Fast Fact Card

Base-station receiver filter utilizes superconductor-based technology

A base-station receiver filter is **Illinois Superconductor's** first superconductor-based product for the wireless telecommunications industry. The filter uses high-temperature superconductors to help cellular system operators improve receiver sensitivity, minimize interference and increase system capacity. The superconductor filter technology provides sharp rejection of undesired radio signals while maintaining a highly efficient power curve. The filter will be available later this year.

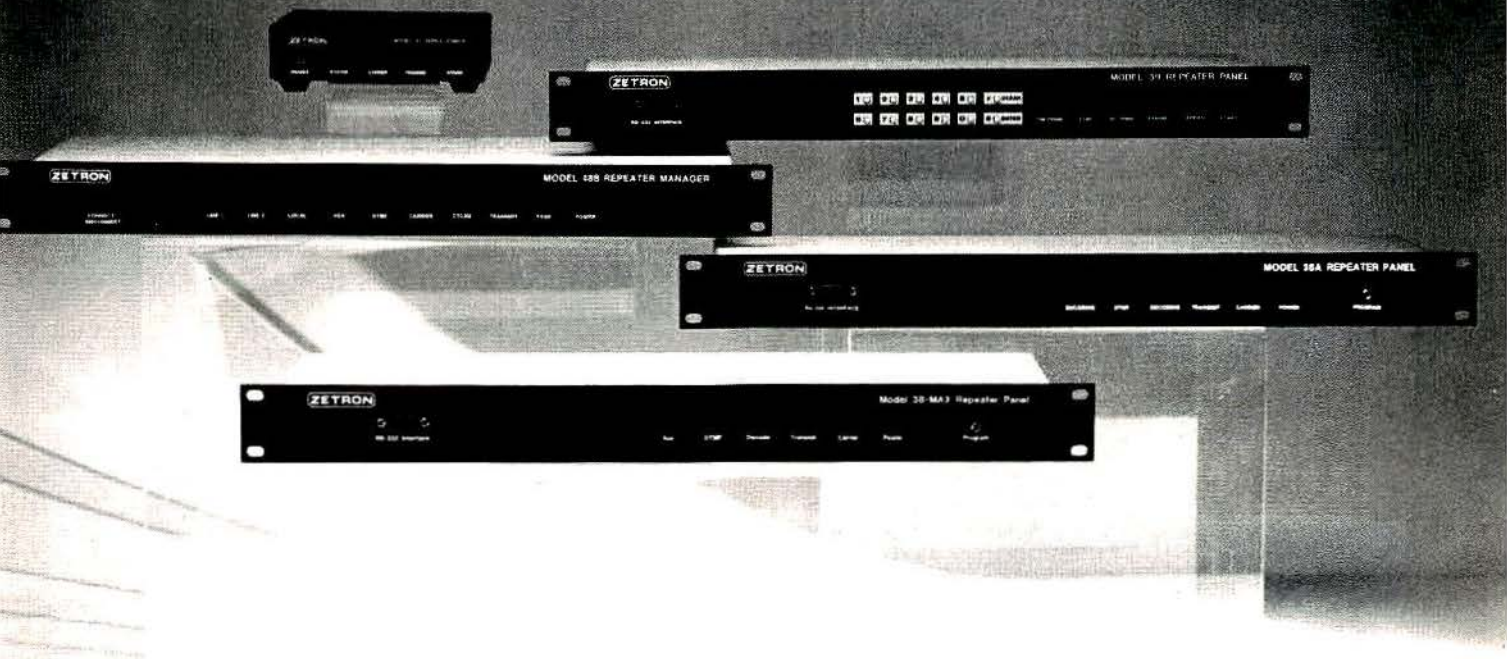
Circle (368) on Fast Fact Card

Computerized system incorporates paging scheduler, remote controller

The Megapage computerized paging system from **Marketronics** allows subscribers to be selectively paged in various subgroups. In addition to real-time paging, an agenda-type format can send pages automatically at predetermined times. Messages for remote wireless controlled electronic LED signs can be prepared for transmission at a later time. Message composition, special effects and display sequence are selected from user-friendly menus. Remote control of lights, alarms, control points, relays and other uses also can be preprogrammed for scheduled execution. Megapage is compatible with tone, numeric or alphanumeric pagers in both GSC and POCSAG digital formats.

Circle (369) on Fast Fact Card

Tone Panels That WORK



A hardworking tone panel should decode a CTCSS/DCS signal even when the radio moves into a fringe area. It should prevent a noisy squelch tail when a user releases the PTT button. Technical problems should be nonexistent. In other words, a tone panel should WORK !

All five models of Zetron's tone panels are equipped with ToneLock, a pioneering decoding circuit that holds onto a weak CTCSS/DCS even if the signal drops below 4dB SINAD. Squelch tails are eliminated before they begin, using rapid CTCSS reverse-burst detect and DCS turn-off codes. Excellent engineering means reliable performance. (How well does your current system work?)

Don't work on your tone panel. Let it work for you.

Model 38-MAX Repeater Panel
High capacity 160 user groups (50 CTCSS, 110 DCS) for scan-based trunking systems or other applications that require numerous tones/codes. Airtime graphs (viewed on PC or hardcopy) reveal channel's tone/code distribution.

Model 48B Repeater Manager
Full-featured community panel with two-line, multi-user telephone interconnect and selective calling.

Model 39 Premium Panel
Handles up to 160 user groups simultaneously and provides a convenient, front-panel keypad and LCD.

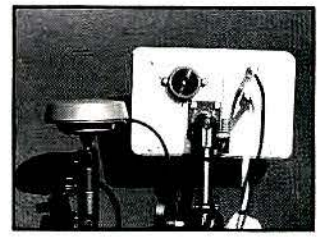
Model 38A Repeater Panel
Most popular tone panel in the industry. Includes RS-232 programming and 38 CTCSS/22 DCS.

Model 37 RepeaterMan
Two CTCSS tones for small systems. Can be used with two radios as a "repeater maker."

Zetron Inc. 12335 134th Ct. N.E. Redmond WA 98052 ZETRON® Ph: (206) 820-6363 Fax: (206) 820-7031

Circle (85) on Fast Fact Card

AVL feature expands mobile data terminal capabilities



Dinet has added an automatic vehicle location (AVL) feature to its line of Data Mate mobile data terminals. The AVL feature incorporates a Global Positioning System (GPS) receiver module in the data terminal case. A vehicle roof-mounted GPS antenna is connected to a BNC connector on the rear of the mobile terminal (photo, above right). With this addtion, all transmissions initiated by the driver are sent to base with the location data included. Location data include latitude, longitude, speed and heading of the vehicle at the time of transmission. Updates are also transmitted on demand through a poll mobile function initiated by the dispatcher or by the base software application. When the received status and location data are applied to a third-party mapping software, vehicle icons can be positioned on a digitized area map on a color computer monitor.

Circle (370) on Fast Fact Card

Pager brings higher-end features to consumer market

The Memo Express alphanumeric pager from **Motorola** receives and displays messages of as many as 120 characters. Designed for the consumer market, the pager allows users to select their incoming message signal from several different audible alerts or a silent vibration. The Memo Express time stamps each message and can store as many as 15 messages in memory. The time and tone functions also perform as an alarm clock. Users control the speed and the format for viewing messages—line by line or scrolled across the backlit display. The pager, with holster, comes in six colors.

Circle (371) on Fast Fact Card

Wide configuration range enhances VHF, UHF portables

Multitone, multiformat (MTMF) VHF and UHF portables from **Haewa Communications** feature front-panel, field-programmable signaling capabilities that include two tone, five tone, CTCSS, ANI, DTMF, pulse tone, burst tone, European five tone and IMTS. Configurations are available for domestic and international formats.

Circle (372) on Fast Fact Card

Literature

Catalog covers FM radio products

A 20-page color catalog, "Better Tools for Productivity," provides graphics, text and specifications for **Earmark's** range of FM radio products. The catalog presents a non-technical approach to understanding the company's team-focused communications systems for working in hostile industrial environments. It includes features and benefits of self-contained, radio headsets, Belt-Paks and repeating base stations, as well as a section on selecting the best product combinations for many industrial situations.

Circle (300) on Fast Fact Card

Catalog lists SMA connectors

A 28-page free catalog from **RF Industries** presents an expanded range of SMA connectors. The connectors are designed to offer reliable broadband performance from dc to 18GHz at a consistent 50Ω impedance. They feature high mechanical strength, high durability and low VSWR. The SMA series will encompass connectors for flexible as well as semi-rigid cable and will include in-series adapters and between-series adapters.

Circle (301) on Fast Fact Card

Catalog targets cellular agents, resellers

A mini catalog designed for the cellular agent and reseller uses easily understandable descriptions and pictures to identify the most popular items. It lists accessories for specific phone models followed by general accessories organized in a simple manner. The mini catalog from **Hutton Communications** was designed to make it easy for customers to close the sale.

Circle (302) on Fast Fact Card

People

Dennis Keith Baker leaves Decibel Products, Dallas, as national sales and product manager of Microcell Systems to join Illinois Superconductor, Evanston, IL, as director of cellular and wireless marketing.

William R. Mansfield exits Prairietek as senior vice president to join CenCall Communications, Denver, as executive vice president.

Changes at Photocomm, Scottsdale, AZ:

Myron Anduri, Industrial Division vice president, advances to senior vice president of marketing and sales.

Steve McCarney, regional manager working out of Puerto Rico, moves up to vice president of international sales.

Changes at Transcrypt International, Lincoln, NE:

Alex Heredia leaves LACC, a consulting group, as president to join Transcrypt as international manager of Latin American sales.

Steve Cass, manager of domestic sales, moves to international manager of Asia/Pacific and Middle East/Africa.

Eric Munro leaves Motorola's Paging Products Group, Boynton Beach, FL, as director of distribution to join Transcrypt as marketing vice president.

Alan Stewart, vice president of marketing and sales, moves up to vice president of international business development.

Scott Falconer leaves PacTel Cellular's corporate marketing group as managing director of distribution and pricing to join Cellular One, Worthington, OH, as senior vice president of marketing.

Letters from readers

Emergency repeater:

Terry Ellis' article about converting Mitreks into repeaters in the Sept. '93 issue was very useful, and when I mentioned it on an amateur radio packet BBS, I got queries from all over Canada and the United States about where I saw the article. There were two items, however, that Terry left unclear.

We are using a Mitrek here in Toronto as a UHF ham repeater, and our mods are similar to those described in the article; however, we had to separate the antenna line from the transmitter and receiver in order to duplex the input and output, and to provide the required connections to a cavity and duplexer. I didn't see any mention of this in the article, and I don't see how the project would work if you just left the antenna jack "as is" and hooked up the antenna!

Also, I believe we had to do some mods to keep both the tx and rx sections of the radio supplied with 12Vdc so that simultaneous transmit and receive was possible. There is no "hang-time" in this repeat mode. The transmitter stays up only as long as there is a carrier at the receive frequency. We built in a cable with an XLR type jack for connection to PTT and the audio lines so that in the future we could add a repeater controller, autopatch and identifier.

John Mckay, P. Eng.
LeBlanc & Royle Telecom
Oakville, Ontario
Canada

Fast Fact Card comments:

The two toughest problems facing me on the job are:

- Parts availability.
- Big business competition and government taxation.

Chris Morgan
Chris Sports & Electronics
Citrus Heights, CA

The two toughest problems facing me on the job are:

- Unlicensed operations.
- Too much red tape in filing and coordinations, and then still getting a frequency on your neighbor's channel.

Mike Haddix
M&L Electronics
Metcalf, IL

The two toughest problems facing me on the job are:

- Quick turnaround.
- Quick vendor response.

David A. Jones Sr.
CommWorld
Vineland, NJ

The toughest problem facing me on the job is people who buy amateur radio equipment and want it modified for business use.

Bruno Boulaine
Air Canada
Laval, Quebec

The two toughest problems facing me on the job are:

- Finding good-quality test equipment for my company at a reasonable price.
- Troubleshooting surface-mount devices on circuit boards.

Brian Walker
A. O. C.
Madisonville, KY

Mobile Radio Technology

The journal of mobile communications technology

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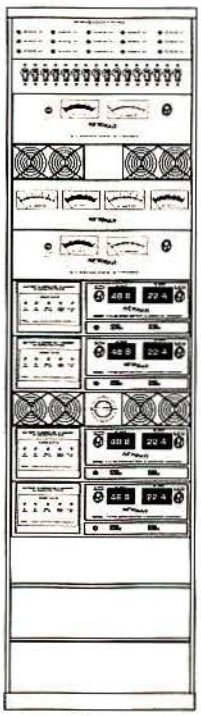

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Motorola Micor U51RTN1100 42-50 60 watt w/acc., no PL	$125
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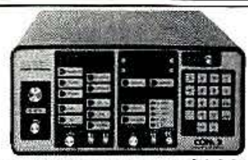

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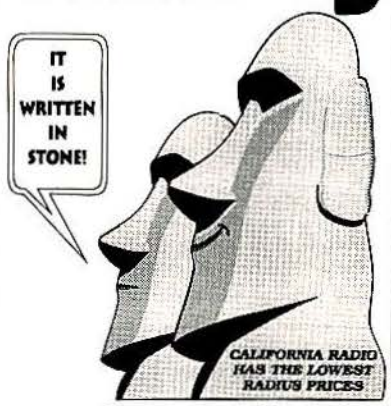

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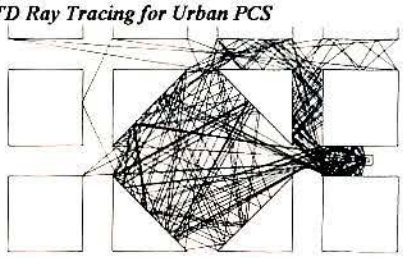

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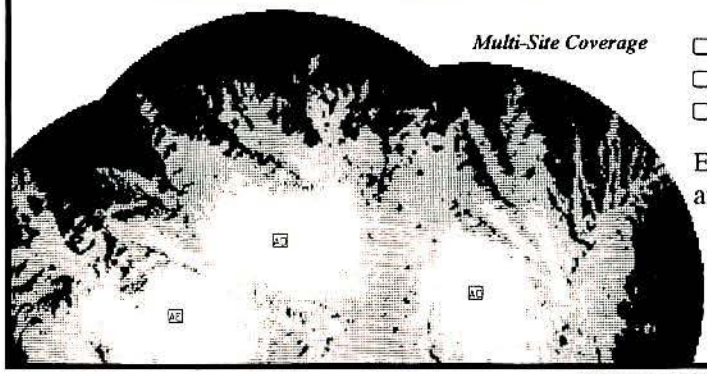

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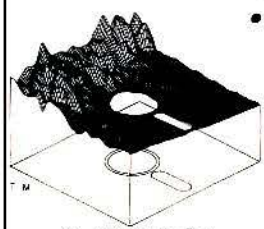

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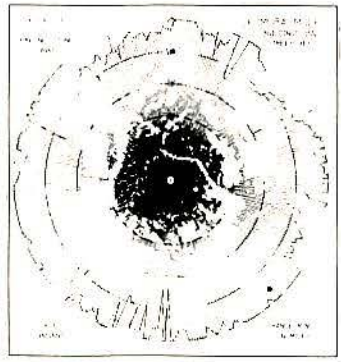

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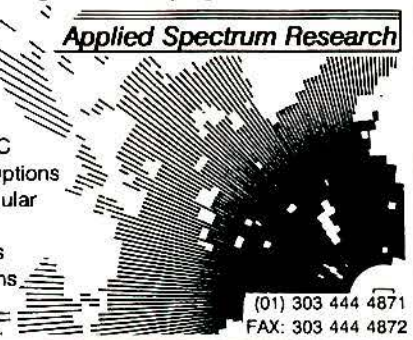

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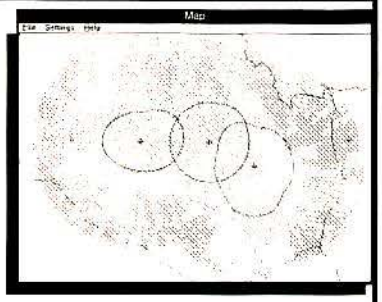

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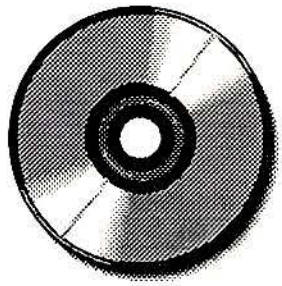

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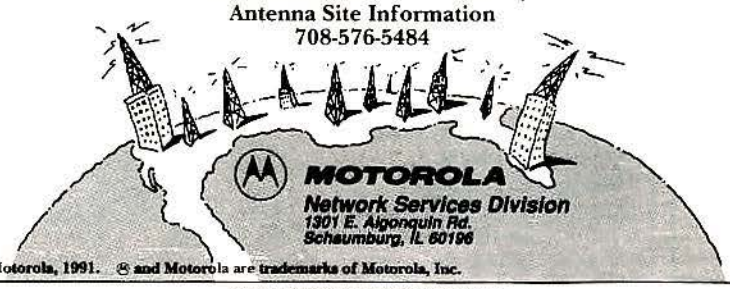

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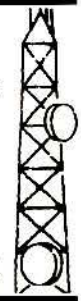

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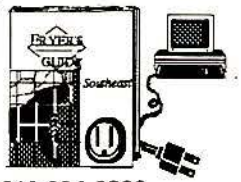

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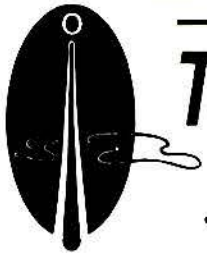

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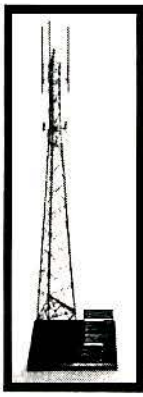

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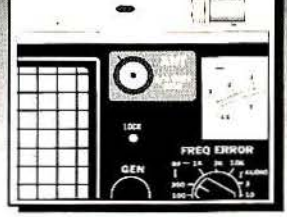

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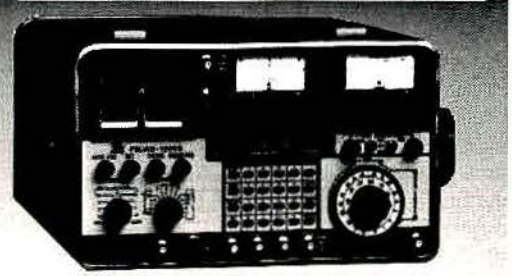

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Ad index/hot line

Company	Page Number	Fast Fact Number	Advertiser Hotline
AAT Communications Corp.	101	132	908-417-3993
Advanced Receiver Research	30	26	203-582-9409
Alexander Batteries	73,75	69,72	800-526-ALEX
Allen Telecom Group	IFC	1	800-229-4706
Allen Telecom Group	24-25	22	216-349-8400
Andrew Corp.	29	25	708-349-3300
The Antenna Farm	87	93	800-255-6222
Astron Corp.	15	12	714-458-7277
Automation & Electronics Engr.	90	102	800-527-4596
Auto-Trac Inc.	34	29	214-480-8145
BEE Electronics Inc.	22	20	708-345-0337
Bramco Inc.	95	119	513-773-6255
Cadex Electronics Inc.	77	71	604-451-7900
Cartwright Communications	72	67	800-543-8614
CELWAVE	21	18	800-321-4700
Centurion International, Inc.	9	7	800-228-4563
C.E.T., Inc.	83	86	904-426-0014
Chargeguard Corp.	91	104	800-458-3410
Christie Electric Corp.	78	77	310-715-1402
Cimarron Technologies	23	21	800-487-7184
David Clark Co., Inc.	14	11	508-751-5800
Combined Technologies Inc.	22	19	513-595-5900
Communication Instruments	103	136	303-962-9998
Communications Associates	91	112	800-435-9313
Communications Data Services	100	128	800-441-0034
Communications Specialists	BC	3	800-854-0547
Commworld Corp.	88	95	800-240-5122
COMTELCO Industries Inc.	50	43	800-634-4622
Connect Systems Inc.	13	10	800-545-1349
Control Signal Corp.	20	16	303-989-8000
CPI Communications, Inc.	63	55	214-437-5320
Cruisers	63,65	54,57	800-963-2580
Cruisers	67,69	69,63	800-963-2580
Cushcraft/Signals Corp.	33	28	800-258-3860
Daniels Electronics	54	47	604-382-8268
Diablo Communications, Inc.	102	134	510-236-3700
D & L Communications Inc.	12,90	9,103	219-484-0466
D & L Communications Inc.	93,97	114,121	219-484-0466
Doppler Systems, Inc.	74	70	602-488-9755
Duracom	88	96	800-467-6741
Dynatech Tactical Comms	20	17	603-880-4411
Eagle Wichita	80	80	316-265-2050
EDX Engineering Inc.	98	123	503-345-0019
Elite Buildings	76	74	800-942-4667
E Trunk Systems, Inc.	92	111	914-245-1128
Everon America, Inc.	40-41	35	800-603-3766
Freeman Engineering Assoc.	45	38	504-831-7785
Frequency Management	91	105	800-800-9825
Fryer's Site Guide	101	131	215-284-9289
Henry Radio	67,89	61,100	800-877-7979
Hewlett Packard	38	33	509-921-4001
Hustler, Inc.	27	24	800-949-9490
Hutton Communications	18	14	800-442-3811
Hy-Q International	89	99	606-283-5000
ICT Systems, Inc.	78	76	800-779-1917
IFR Systems, Inc.	47	40	316-522-4981
Interactive Systems, Inc.	82	78	703-812-8270
Intl. Public Safety Assoc.	66	59	203-847-9679
JBRO Batteries Inc.	11	8	800-323-3779
Larsen Electronics	35	30	800-426-1656
Lazer Beepers, Inc.	102	135	800-354-3405
Maxrad, Inc.	59	51	800-323-9122
McManus Communications	87		501-763-6250
Mechem Electronics	93	113	703-373-3888
Megahertz Technology, Inc.	90	101	214-341-1119
Meridian Communications	43	37	818-888-7000
Midian Electronics Inc.	37	32	800-MID-IANS
Midland International LMR	65	58	800-MID-LAND
Modular Communication Systems	71	66	818-764-1333
Monark International Corp.	46	39	816-891-0700
Motorola C & E	39,100	34,130	708-576-5484
Motorola Government	17	13	800-235-9590
Motorola GPID	31	27	800-367-2864
Motorola Page Care Centers	60,95	52,120	407-364-2966
MX-Com, Inc.	7	6	800-638-5577
N.A.B.E.R.	97	122	800-759-0300
NATCOM,Inc.	36,82	31,83	800-844-8287
New Mar	89	98	800-854-3906
Norton Engineering	99	125	703-938-5745
Orbacom Systems Inc.	61	84	609-829-4455
PanaVise Products Inc.	70	65	702-353-2900
Pekaar Communication, Inc.	92	110	201-772-0704
Percon Corporation	100	129	716-386-6015
Photocomm, Inc.	80	81	800-223-9580
Polaris Industries	87	94	800-752-3571
Polyphaser Corp.	62	53	800-325-7170
Pyramid Communications	91		414-730-4190
Rabun Labs	89	97	800-788-1824
The Radio Shop	107	113	713-526-8000
Radio Wholesale	92	109	800-53R-ADIO
Ramsey Electronics	94	117	716-924-4560
RCW Distributing	91	107	800-726-9015
Rocky Mountain Comms, Inc.	98		303-526-5454
Santa Fe Distributing	52	45	913-492-8288
Scala Electronic Corp.	81	82	503-779-6500
Schlumberger Technologies	19	15	800-225-5765
Selectone Corporation	5	5	800-227-0376
Sentry USA	99	126	407-773-6090
Sharp Communication	93	115	800-548-2484
Shinwa Communications of Am.	48	41	800-627-4722
Softwright	98	124	303-344-5486
Solar Electric Specialties	76	73	800-344-2003
Stancil Corporation	57	50	714-546-2002
Standard Communications	51	44	800-767-6695
TAD Radio	81	79	509-326-1511
Tait Electronics	53	46	
Tait Electronics USA, Inc.	26	23	713-984-8684
Telephonics	64	56	516-549-6300
Telepoint, Inc.	77	75	310-652-3666
Telewave, Inc.	68	62	415-968-4400
Telex Communications, Inc.	69	64	800-554-0716
Times Microwave Systems	42	36	203-949-8400
Towerwatch	102	133	913-233-2343
Transcrypt International Ltd	3		800-228-0226
Trident Micro Systems	55	48	800-798-7881
Vega, A Mark IV Company	1	4	818-442-0782
Versatel Communications	92	108	800-456-5548
Vertex/Yaesu USA	IBC	2	310-404-2700
Vocom/RF Corporation	72	68	800-USA-MADE
Wetec Electronics	94	116,118	800-249-1250
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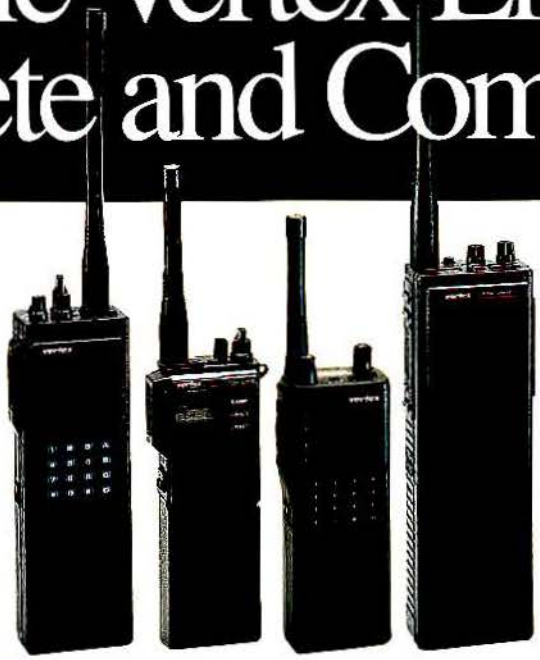

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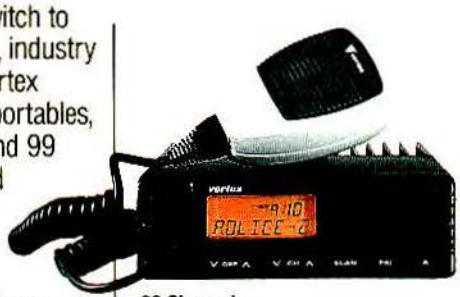

99 Channel
Synthesized Wideband Mobile Radios

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Synthesized Wideband Mobile Radios

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134-174 MHz, 40 Watt
FTL-7011 UHF:
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FT-80C HF SSB Transceiver
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Circle (2) on Fast Fact Card

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